REMEDIAL INVESTIGATION WORK PLAN

FARRAND CONTROLS SITE
VALHALLA, WESTCHESTER COUNTY, NEW YORK 10595

NYSDEC Site No. 360046

Work Assignment No. D009812-30

Prepared for:

NEW YORK STATE Department of Environmental Conservation

Division of Environmental Remediation
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TRC Project 489357.0000.0000

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Acronyms and Abbreviations

ASP	New York State Department of Environmental Conservation Analytical Services Protocol
ASP-B	New York State Department of Environmental Conservation Analytical Services Protocol Category B
bgs	Below Ground Surface
Cascade	Cascade Drilling, L.P.
CAMP	Community Air Monitoring Plan
COCs	Contaminants of Concern
CP-49	New York State Department of Environmental Conservation, Commissioner Policy 49, Climate Change and DEC Action
CSM	Conceptual Site Model
CVOCs	Chlorinated Volatile Organic Compounds
DER	New York State Department of Environmental Conservation Division of Environmental Remediation
DER-10	New York State Department of Environmental Conservation, Division of Environmental Remediation, Technical Guidance for Site Investigation and Remediation

Acronyms and Abbreviations (cont.)

DER-31	New York State Department of Environmental Conservation, Division of Environmental Remediation, Technical Guidance for Green Remediation
DNAPL	Dense Non-aqueous Phase Liquid
DOT	Department of Transportation
DUSRs	Data Usability Summary Reports
EDDs	Electronic Data Deliverables
EM/RF	Electro-Magnetic/Radio Frequency
EQuIS	Environmental Quality Information System
FAP	Field Activities Plan
f/k/a	Formerly Known As
FACT	FLUTe Activated Carbon Technique
FLUTe	Flexible Liner Underground Technologies, Inc.
FS	Feasibility Study
GPR	Ground Penetrating Radar
GPRS	Ground Penetrating Radar Systems, Inc.
GSR	Green and Sustainable Remediation
HASP	Health and Safety Plan
HRGS	Hager-Richter Geoscience, Inc.
IA	Indoor Air
IDW	Investigation Derived Waste
IRM	Interim Remedial Measure
LKMA	L.K. McLean Associates, P.C.
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPL	Non-aqueous Phase Liquid
NTUs	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
PEJA	Potential Environmental Justice Area
PID	Photoionization Detector
PPE	Personal Protective Equipment
PVC	Poly-vinyl Chloride

Acronyms and Abbreviations (cont.)

QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROW	Right-of-Way
SCGs	Standards, Criteria, and Guidance
SIM	Selective Ion Monitoring
Site	Farrand Controls, 99 Wall Street, Valhalla, Westchester County, New York
SOW	Scope of Work
SSDS	Sub-Slab Depressurization System
SSHASP	Site-specific Health and Safety Plan
TBD	To Be Determined
TCE	Trichloroethene
TCL	Target Compound List
TICs	Tentatively Identified Compounds
TRC	TRC Engineers, Inc.
USCS	Unified Soil Classification System
TSP	Taconic State Parkway
USEPA	United States Environmental Protection Agency
USEPA Method TO-15	United States Environmental Protection Agency, Compendium of Methods - Determination of Volatile Organic Compounds In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography Mass Spectrometry
VOCs	Volatile Organic Compounds
WA	Work Assignment

1.0 Introduction

TRC Engineers, Inc. (TRC) has prepared this Remedial Investigation (RI) Work Plan (Work Plan) to describe the RI activities to be performed at the Farrand Controls Site ("the Site"), which is located at 99 Wall Street, in Valhalla, Westchester County, New York. The Site is designated by the New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation (DER) Site No. 360046 under its Inactive Hazardous Waste Disposal Site Program (New York State Superfund Program).

This Work Plan supersedes a previous version which was submitted to the NYSDEC on June 9, 2023. This version incorporates NYSDEC comments concerning the previous version which were generated with the NYSDEC's consultation with the New York State Department of Health (NYSDOH) and received via letter dated September 6, 2023.

TRC will complete the RI activities discussed in this Work Plan in accordance with the March 23, 2023, NYSDEC DER Work Assignment (WA) Approval Letter for Standby Engineering Services Contract No. D009812 for a Remedial Investigation/Feasibility Study (RI/FS), the February 21, 2023, NYSDEC-approved Scope of Work (SOW), and NYSDEC DER-10, Technical Guidance for Site Investigation and Remediation (DER-10).

The purpose of the RI activities described in this Work Plan is to expand upon prior investigations to further define the nature and extent of any contamination resulting from previous Site activities, and to provide an expanded knowledge of Site conditions for re-examining remediation goals and remedy selection.

Section 2.0 of this Work Plan describes Site conditions and history, specifically including Site location and setting, Site features and use, topography and Site drainage, regional geology and hydrogeology, and previous investigations and remedial measures. **Section 3.0** presents general information pertaining to the project and work to be performed, while **Sections 4.0** and **5.0** describe the details of the RI work activities to be perform. Finally, **Section 6.0** outlines the schedule for completion of the work. Various tables, figures, and appendices are referenced throughout this Work Plan as containing supporting information.

2.0 SITE DESCRIPTION AND HISTORY

2.1 Site Location and Setting

The Site is located along the north side of Wall Street in the Town of Mount Pleasant, Westchester County, Valhalla, New York. The Site property is 13.6 acres in size. The northeastern area, approximately 60 percent of the property, is a hill with a bedrock outcrop at its base and is undeveloped. The developed areas of the property extend from the bedrock outcrop to the property boundaries to the northwest, west and south, and is referred to as the "Site".

The Site is currently owned by Ruhle Companies, Inc. (f/k/a Farrand Controls, Inc.), and is an inactive electronic component manufacturing facility. A residential area adjoins the Site to the south and a light industrial park is located to the north. A wetland area and Davis Brook lie to the west, between Wall Street and the Taconic State Parkway. **Figures 1** and **2** illustrate the location and layout of the Site, respectively.

2.2 Site Features and Use

The Site is mostly covered with asphalt or grass and serviced by municipal water, sewer, and natural gas systems. The Site contains a 28,255-square foot, one-story block- and steel-framed manufacturing building constructed in 1958 for operations consisting of machining of metals, photolithographic processing (including cupric etching), soldering, and electronic and mechanical assembly. There is also an 8,312-square foot, wood-framed Quonset-style building on the Site, which was constructed as an indoor tennis court, also in 1958.

2.3 Topography and Site Drainage

The Site and the surrounding area have an apparent topographic slope to the south-southwest toward the wetland area and Davis Brook located approximately 50-feet southwest of the Site on the opposite side of Wall Street.

Storm water is collected by an on-site storm sewer system that discharges into the wetlands identified above. Three active sumps are located in the basement of the main manufacturing building. The sumps are used to collect groundwater infiltration and convey it via pumps to the adjacent wetlands via the Site storm sewer system.

2.4 Regional Geology and Hydrogeology

The Site and surrounding area are part of the New England uplands physiographic province. Bedrock consists of Precambrian and Paleozoic sedimentary and igneous rocks that have been highly metamorphosed and complexly folded and faulted. In the vicinity of the Site, bedrock is mapped as likely belonging to the Manhattan formation. (Geologic Map of New York State, Lower Hudson Sheet [Fischer, Isachsen and Rickard, 1970[1]]).

The Manhattan formation consists of pelitic, garnet-amphibolite schist and gneiss. Near the Valhalla area, the formation is considered to be of Cambrian age. The moderate relief that characterizes the area is attributed to differences in the relative hardness of the underlying bedrock. Drainages have developed in areas of softer, more easily eroded bedrock and in weathered shear zones where faulting has weakened bedrock. These structural and lithologic controls on drainage produced the area's ridge-and-valley topography. Glacial erosion subsequently modified the landscape. During glacial retreat, deposition of sediments as till, outwash and moraines produced a complicated unconsolidated veneer above low-lying bedrock. The Surficial Geologic Map of New York State, Lower Hudson Sheet (Caldwell, 1970[2]) describes this veneer as "poorly sorted, variably textured diamict deposited beneath glacial ice."

The shallow water table in the region occurs in unconsolidated deposits overlying bedrock in the lowlands. The shallow groundwater flows from the highlands toward the valley lows. In the Site vicinity, this direction is generally southward. Groundwater at depth also occurs in the fractured bedrock.

On June 20, 2014, synoptic groundwater level measurements were obtained from all existing and newly installed Site groundwater monitoring wells/piezometers for determining groundwater elevations and flow direction [D&B Engineers & Architects, P.C. (D&B), September 2015[3]]. These data indicate that overburden groundwater at the Site is encountered at depths ranging from approximately 2 to 12 feet below ground surface and elevations of 245.52 feet to 238.74 feet and generally flows southward.
Groundwater in the fractured bedrock beneath the overburden deposits occurs at depths ranging from approximately 39.63 feet to 98.35 feet below ground surface and elevations of 241.56 feet to 221.48 feet.

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[1] Fisher, D.W. et al, 1970, Lower Hudson Sheet – Geologic Map of New York State, New York State Museum and Science Service: map.

[2] Caldwell, D.H. et al, 1970, Lower Hudson Sheet – Surficial Geologic Map of New York State New York State Museum and Science Service: map.

[3] D&B Engineers & Architects, P.C. Environmental Sampling and Implementation Program Final Report, Farrand Controls Site, Westchester County, New York, NYSDEC Site No. 360046. September 2015.

Drainage from the area surrounding the Site is primarily to the southeast toward the Bronx River. To the south, the Bronx River becomes the Hutchinson River and empties into Long Island Sound at Eastchester Bay. In the vicinity of the Site, drainage is partly contained internally in valley floor ponds.

2.5 Previous Investigations

For an unknown period, spent solvent wastes were collected in a basement sump in the main manufacturing building, which was connected to various floor drains throughout the building. During an expansion of the facility in 1969, the basement sump was deactivated, and hazardous waste liquids were released to groundwater. An exterior catch basin east of the southeast corner of the main building was also apparently used for waste disposal for an unknown period. Spent solvents (primarily trichloroethene [TCE]) were apparently historically released to the subsurface through the basement sump. As a result, volatile organic compounds (VOCs) have impacted overburden groundwater, bedrock groundwater, surface water and indoor air at the Site.

During an environmental assessment by the Site owner in 1993, on-site groundwater was found to be contaminated with chlorinated solvents. Over the next few years, the Site owner conducted investigations and installed several groundwater monitoring wells to determine the full extent of contamination. In 1996, the owner removed the contents of the basement sump and the underlying contaminated shallow soil.

In 1995, the NYSDEC identified the Site as an inactive hazardous waste disposal site and listed it in the Registry of Inactive Hazardous Waste Disposal Sites in New York as a Class 2 site. A Class 2 site is a site where hazardous waste represents a significant threat to human health or the environment and requires action. Negotiations subsequently began with current and previous Site owners to undertake a complete remedial program for the Site. Although these negotiation efforts were unsuccessful, the NYSDEC is continuing with investigative activities for the Site under the New York State Superfund Program.

Two primary investigations of the Site have been completed – an initial RI in 2000 and a subsequent environmental sampling program in 2015. These investigations identified several contaminants of concern (COCs), including chlorinated VOCs (CVOCs) and Freon-113, in Site overburden and bedrock groundwater, as well as in sediment and surface water in an adjacent wetland area.

The highest VOC concentrations at the Site exist in the bedrock monitoring wells located southeast of the facility building (MW-21R and MW-22R). MW-10R, which is also a bedrock monitoring well and is located southeast of the facility building just south of Wall Street, also exhibited elevated VOCs. However, MW-20R, which is a bedrock well located southeast of the wetland area along the Taconic State Parkway, did not exhibit any detectable VOCs.

The results of a well pumping test performed in 2014 appear to confirm prior conclusions that dense non-aqueous phase liquid (DNAPL) likely exists in the bedrock, since stressing the bedrock with more aggressive pumping resulted in a significant increase in site-related VOC concentrations detected in the samples collected as part of the program.

In 2010, as part of the prior investigation work, NYSDEC and NYSDOH concluded that soil vapor intrusion pathways were evaluated and that there were no off-Site exposures. Potential on-Site soil vapor intrusion exposures for the main building were subsequently addressed by the Site owner by sealing all significant cracks in the concrete floor slab, sealing the open sumps, modifying the building's HVAC equipment for fresh air intake, and installing five sub-slab depressurization systems (SSDS) along the length of the building. These measures are currently in place and functioning. Effectiveness of the measures will be further evaluated as part of the upcoming investigation work.

Details concerning these investigations are reported, respectively, in reports preprepared by Dvirka & Bartilucci Consulting Engineers, August 2000[4], and D&B, September 2015[5].

As documented by D&B, January 2017[6], an additional investigation of sediment was conducted in 2016 to delineate an area targeted for sediment removal within the wetland area west of the Site between Wall Street and the Taconic State Parkway. Based on the results of this investigation, no further sediment sampling and analyses were deemed necessary to proceed with the next phase of the project.

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[4] Dvirka & Bartilucci Consulting Engineers. Remedial Investigation Report, Farrand Controls Site, Valhalla, New York, Site Registry No. 3-60-046. August 2000.

[5] D&B Engineers & Architects, P.C. Environmental Sampling and Implementation Program Final Report, Farrand Controls Site, Westchester County, New York, NYSDEC Site No. 360046. September 2015.

[6] D&B Engineers & Architects, P.C. Letter From: James J. Magda, Project Manager. To: Jeffrey E. Trad, P.E., New York State Department of Environmental Conservation, Division of Environmental Remediation. RE: Farrand Controls Site, NYSDEC Site No. 360046, Contract/WA No. D007620-16.1, Supplemental Sediment Sampling Summary Report, D&B No. 3150-16. January 10, 2017.

Additional groundwater samples collected in 2019 by D&B show that high concentrations of Site COCs remain in groundwater, particularly in bedrock, at levels potentially indicative of dense non-aqueous phase liquid DNAPL. Horizontal and vertical extents of the groundwater contaminant plume have not been delineated. The results of this investigation have not been formally documented. Such information will be included in the Phase I RI Report further discussed in **Section 4.11**.

2.6 Previous Remedial Measures

Suspected source areas of contamination at the Site have been reported to consist of the basement sump and storm water catch basin mentioned above in **Section 2.5** along with suspected DNAPL on and/or within fractured bedrock underlying the Site.

Two of the three potential source areas have been addressed through Interim Remedial Measures (IRMs). The basement sump was cleaned, and subsurface soil was removed by the owner prior to the NYSDEC's involvement at the Site. Contaminated soil located within and adjacent to the storm water catch basin was addressed by the NYSDEC in 2008 and documented in Precision Environmental Services, Inc. September 2008.

D&B, October 2000 presents a Feasibility Study (FS) on remedial measures to address the groundwater contamination in the overburden and fractured bedrock. The remedial measures evaluated included groundwater extraction and treatment, in-well air stripping, in-situ chemical oxidation and monitored natural attenuation. Based upon the recommendations of the FS, a bench scale treatability study utilizing permanganate oxidation and zero-valent iron chemical reduction was conducted in December 2001, the results of which suggested that zero-valent iron chemical reduction could be a feasible remedy for the contaminated groundwater at the Site. Subsequently, in accordance with the 2002 NYSDEC Record of Decision (ROD) (NYSDEC, March 2002[7]), two on-site pilot studies were conducted in May 2005 (smaller scale) and November/December 2008 (larger scale). Although the larger scale pilot study successfully injected the zero-valent iron into the subsurface environment, the laboratory analytical results for the post-injection groundwater sampling indicated that the zero valent iron injections had limited impact on improving groundwater quality. Therefore, it

[7] New York State Department of Environmental Conservation, Division of Environmental Remediation. Record of Decision, Farrand Controls Site, Town of Mt. Pleasant, Westchester County, Site Number 3-60-046. March 2002.

was concluded that this technology is not capable of achieving the desired contaminant reduction at the Site.

3.0 GENERAL INFORMATION

3.1 Project Organization

NYSDEC issued a RI/FS WA to TRC under Standby Engineering Services Contract D009812 to complete the RI for the Site. TRC will implement the RI with oversight from NYSDEC using TRC staff and several NYSDEC-approved subcontractors. NYSDEC and Ruhle Companies, Inc. executed an Order on Consent and Administrative Settlement, effective January 7, 2014 (Consent Order), which among other things, established contacts for matters pertaining to the Site as well as the terms and conditions for Site access for the NYSDEC and its representatives during the RI. Contact information for designated representatives is provided below:

Contact information for the Owner:

Mr. Frank S. Ruhle, President
Ruhle Companies, Inc.
99 Wall Street
Valhalla, NY 10595

James J. Periconi, Esq.
Periconi, LLC
260 Madison Avenue, 7th Floor
New York, New York 10016
jpericoni@periconi.com

Contact information for the NYSDEC (updated):

Mr. Mark Domaracki, Project Manager
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Contact information for the NYSDOH:

Mark S. Sergott, P.G., Project Manager
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NYSDEC-approved TRC subcontractors:

Ground Penetrating Radar Systems, Inc. – Utility Locating Services

Hager-Richter Geoscience, Inc. – Borehole Geophysics Services

Cascade Drilling, L.P. – Drilling Services

Innovative Recycling Technologies (WBE) – IDW Disposal Services

L.K. McLean Associates, P.C. – Land Surveying Services

Flexible Liner Underground Technologies – Hydrogeologic Characterization and Multilevel Well Installation

Eurofins TestAmerica – Laboratory Analytical Services

3.2 Permits and Notification

3.2.1 NYSDEC

TRC will provide NYSDEC 10 days advanced notice prior to the start of on-site work pertaining to this Work Plan.

3.2.2 Property Owner

As per the Consent Order, The Owner is to provide the NYSDEC and any agent, consultant, contractor, or other person so authorized by the NYSDEC, an irrevocable right of access at all reasonable times to the Site and to any other property to which access is required for the implementation of response actions at the Site, to the extent access to such other property is controlled by Owner, for the purposes of performing and overseeing response actions it deems necessary at the Site. The NYSDEC is to provide the owner five days' notice of the commencement of any response actions at the Site.

On behalf of the NYSDEC, TRC will provide the Owner with a five days' notice of the start of work pertaining to this Work Plan.

3.2.3 City

Based on a review of City of Valhalla requirements, no permits are required for the implementation of on-site work pertaining to this Work Plan; however, TRC will provide the City with a five days' courtesy notice prior to the start of work in any off-site areas, including City Right of Ways (ROWs).

3.2.4 County

Based on a review of Westchester County requirements, no notices or permits are required for implementation of this Work Plan.

3.2.5 State

The NYSDEC will provide all necessary inter-agency notices that are required and/or appropriate prior to the start of work pertaining to this Work Plan.

TRC will obtain on behalf of the NYSDEC a New York State Department of Transportation (NYSDOT) Highway Work Permit for accessing the Taconic State Parkway (TSP) ROW for installing and sampling monitoring wells within the TSP ROW during Phase II RI activities outlined in **Section 4.0**.

3.2.6 Federal

Based on a review of Federal requirements, no notices or permits are required for implementation of this Work Plan.

3.3 Governing Documents

3.3.1 General

As noted previously in **Section 1.0**, the RI activities discussed in this Work Plan will be conducted in accordance with the March 23, 2023, WA Approval Letter and the February 21, 2023, NYSDEC-approved SOW.

Investigation activities, including sample collection and laboratory analysis, will be completed in accordance with the Standby Engineering Services Contract, 6 New York Codes, Rules and Regulations, Part 375 Environmental Remediation Programs, NYSDEC, Technical Guidance for Site Investigation and Remediation (DER-10), New York State Department of Health Guidance for Evaluating Soil Vapor Intrusion in the State of New York, and other pertinent generic governing documents included in Standby Engineering Services Contract No. D009812, namely the Health and Safety Plan (HASP), Community Air Monitoring Plan (CAMP), Field Activities Plan (FAP), and Quality Assurance Project Plan (QAPP). The generic documents are provided as Appendix A. For any proposed activities not covered in the generic documents, supplemental Site-specific information is discussed below in **Section 3.3.2**.

3.3.2 Site-Specific Modifications

3.3.2.1 Site-Specific HASP

A Site-specific HASP (SSHASP) has been prepared for the activities to be performed under this Work Plan based on the generic HASP and Site-specific HASP template for Standby Engineering Services Contract No. D009812. The SSHASP is provided as Appendix B.

3.3.2.2 CAMP

A CAMP will be implemented (as appropriate) by the TRC scientist/engineer overseeing investigation activities during ground-intrusive activities in accordance with the NYSDOH generic CAMP and HASPs. The CAMP will include real-time monitoring for VOCs and particulates (i.e., dust) at one upwind and one downwind perimeter location during intrusive activities only. It should be noted that the number and location of the downwind perimeter location(s) may be subject to change based on the Site conditions and proximity to sensitive downwind receptors. .

3.3.2.3 Sample Summary

The RI activities further described in **Sections 4.0** and **5.0** below include the collection of and laboratory analysis of additional Site soil, groundwater, sediment and indoor air samples, among other data collection efforts. **Table 1** provides a summary of the various samples to be collected and corresponding laboratory analyses planned, including quality assurance/quality control samples. In general, quality control samples consisting of one field duplicate, and one matrix spike/matrix spike duplicate (MS/MSD) sample will be collected per the QAPP (i.e., at a frequency of one per 20 samples per matrix). Trip blanks will be included in each cooler shipped to the laboratory containing aqueous samples for VOC analysis. Equipment or field blanks will be collected for analysis for VOCs at a frequency of one per 20 samples per matrix.

3.3.2.4 EQuIS, EDDs, and Data Usability Summary Reports

The laboratory analyses summarized in **Table 1** will be performed by a NYSDEC Call-out Laboratory, except for those pertaining to natural attenuation, which will be analyzed by Eurofins TestAmerica, under subcontract to TRC. NYSDEC's Call-out Laboratory will provide NYSDEC Analytical Services Protocol (ASP) Category B (ASP-B) data deliverable packages for VOC analysis and Category A data deliverable packages for natural attenuation parameter and waste characterization analyses. Data Usability Summary Reports (DUSRs) will be prepared by TRC for the analytical results, except for natural attenuation parameter and waste characterization analyses. Electronic Data Deliverables (EDDs) in Environmental Quality Information System (EQuIS) format will be submitted to the NYSDEC.

3.3.2.5 Borehole Geophysics

The RI activities described in further detail in Section **4.0** and **5.0**, include the installation eight bedrock groundwater monitoring wells. Once drilled, each bedrock borehole will be subject to a geophysical survey, which will be performed by Hager-Richter Geoscience, Inc. (HRGS), under subcontract to TRC. HRGS is licensed to offer geological/geophysical services in the state of New York and its on-site work will be supervised by HRGS' New York licensed professional geologists. HRGS will perform fracture trace analysis on each location by the following means:

- Fluid temperature and conductivity logging
- Caliper logging
- Optical and acoustic televiewer
- Heat pulse flow meter under ambient and stress/pumping conditions

The purpose of these surveys is to identify transmissive bedrock fractures following the drilling of each well. Implementation procedures and other information pertaining to the geophysical methods are provided in Appendix C.

3.3.2.6 FLUTe Hydrogeologic Characterizations

Hydrogeological characterizations of bedrock boreholes to be installed during this RI will be performed using Flexible Liner Underground Technologies (FLUTe) liners and profiling methods (Blank liners, FLUTe Activated Carbon Technique [FACT] liners, non-aqueous phase liquids [NAPL] liners, and transmissivity and reverse head profiling) to evaluate contaminant distribution and transmissive properties of the bedrock fractures, and to select monitoring well screen zones.

Following the hydrogeological characterizations, FLUTe will supply and install custom built Water FLUTe systems (multi-level wells) in select bedrock boreholes to monitor groundwater in separate zones at the Site. The results of the hydrogeological characterizations and sampling results from the Water FLUTe systems will be used to support delineation of Site contamination, evaluate contaminant fate and transport in fractured bedrock, and update the conceptual site model (CSM). This information will be used to assess the next steps for the Site. FLUTe's hydrogeological characterization methods and custom-built liners are proprietary/patented and a substitute for traditional remedial investigation methods such as pumping tests, slug tests, packer tests and nested wells.

FLUTe hydrogeological characterization methods and custom-built liners offer several advantages over traditional methods including, but not limited to:

- Increased data precision, accuracy, and reliability.
- Reduced time in the field.
- Sealed bedrock boreholes between work phases to prevent contamination migration within boreholes.
- Rapid mapping of bedrock borehole properties at high resolution (6-inch scale) with no leakage or bypass issues.
- Ability to map pure phase and dissolved phase contaminants at the same time within the same borehole.
- Ability to construct multi-level monitoring wells easily and effectively in a single bedrock borehole.
- Groundwater sampling directly from the formation at multiple levels with little to no purging of groundwater.
- Protection of the bedrock borehole against slough and collapse
- Liners are removeable and warrantied.

Implementation procedures and other information pertaining to the FLUTe hydrogeological characterization methods and custom-built liners are provided in Appendix D.

3.4 Potential Environmental Justice Area

A Potential Environmental Justice Area (PEJA) map will be prepared for the Site based on the NYSDEC's publicly available Geospatial Information System resources. The map will include Site location information, Site boundary, and proximity of the Site to PEJAs. The map will be included in the RI Reports and/or FS, and the mapping results will be considered during the future development and screening of remedial alternatives for the Site, as appropriate.

3.5 Records Search and Site Visit Summary

TRC reviewed available project documents provided by the NYSDEC, to obtain an understanding of the nature and extent of contamination and existing conditions at the Site for the purpose of developing the basis for, and the scope of the work detailed in this Work Plan. TRC performed an initial desktop reconnaissance for pertinent geological reports for the Site, and subsequently performed a Site visit/inspection with the NYSDEC Project Manager on June 24, 2022, to examine the physical features, topography, existing structures, utilities and well locations and access to the Site and surrounding properties.

3.6 Green and Sustainable Remediation

As part of the performance of the work detailed in this Work Plan, TRC will, as feasible and appropriate, implement green remediation and climate change guidance as described in NYSDEC, Green Remediation (DER-31) and Climate Change and DEC Action (CP-49), including, but not limited to, using local staff and subcontractors, grouping field tasks, reducing trips to the Site, using alternate sampling techniques, minimizing waste generation, using renewable energy, optimizing remedial alternatives, and tracking and reporting green and sustainable remediation metrics. Metrics will be aligned with United States Environmental Protection Agency (USEPA's) green sustainable remediation (GSR) core elements and greener cleanup metrics and consider both best management practices and site-specific actions. A GSR metrics summary will be included in the RI Reports.

4.0 PHASE I REMEDIAL INVESTIGATION ACTIVITIES

The following Scope of Work describes a phased investigation, with the objective of further defining the nature and extent of contamination, and preparation of Phase I and Phase II RI Reports. This Scope of Work has been prepared based on a thorough review of available project documents provided by the NYSDEC, to obtain an understanding of the nature and extent of contamination and existing conditions at the Site. Additionally, a Site visit/inspection was performed with the NYSDEC Project Manager on June 24, 2022, to examine the physical features, topography, existing structures, utilities and well locations and access to the Site and surrounding properties.

4.1 Initial Activities

TRC will prepare for the RI and coordinate field work with the NYSDEC call-out laboratory and TRC utility locating, video inspection, drilling, borehole geophysical, FLUTe, investigation-derived Waste (IDW) management, and land surveying subcontractors. TRC will confirm that the drilling subcontractor has contacted UDig NY (or appropriate utility locating service), received/reviewed utility confirmation receipts, and verified public utility mark-outs prior to intrusive work.

4.1.1 UDig and Utility Locating Survey

Prior to intrusive activities, a private utility locating survey will be conducted by Ground Penetrating Radar Systems, Inc. (GPRS), in addition to the public utility mark outs, to clear proposed monitoring well locations (shown on **Figure** 1). Vegetation clearing may be required prior to the utility locating survey and will be coordinated by TRC with the appropriate property owners. GPRS will survey the area using, at a minimum, both Ground Penetrating Radar (GPR) and Electro-Magnetic/Radio Frequency (EM/RF) Pipe, Cable and Box locaters within an approximate 10-foot radius around each proposed investigation location. Subsurface utilities/structures/anomalies will be identified on the ground surface with spray paint and/or pin flags. TRC will discuss any required monitoring well repositioning, due to identified subsurface utilities/structures/anomalies, with the NYSDEC Project Manager prior to installation. It is anticipated that minor offsets (10 feet or less) will not require prior notification/approval.

4.1.2 Inspection and Re-development of Existing Monitoring Wells

The existing Site monitoring wells and piezometers (up to 49 based on project documents, and as shown on **Figure 1**) will be inspected to assess condition (Note: It is unclear if the piezometers still exist.) The existing wells and piezometers (hereinafter referred to as “existing wells”) will be gauged using a water-level meter for depth to water, total depth of the well, and depth to NAPL (if found). The results will be compared to the available well construction information. If an existing well is found to require redevelopment (i.e., silt accumulation - the measured bottom of the well is shallower than the documented construction depth), it will be redeveloped as part of the work described below in **Section 4.6**. TRC will utilize the Monitoring Well Inspection Form included in the FAP to document the condition of the existing wells and will evaluate if repairs are needed.

4.1.3 Initial Sampling and Analysis Activities

Initial sampling and analysis activities will consist of sump water sampling in the basement of the main manufacturing building and surface water sampling from the wetland located approximately 50-feet southwest of the Site on the opposite side of Wall Street.

4.1.3.1 Sump Water

Water samples will be collected from the three basement sumps within the existing building (shown on **Figure 1**) and analyzed for Target Compound List (TCL) VOCs, plus 10 Tentatively Identified Compounds (TICs) – low level.

4.1.3.2 Surface Water

Surface Water Sampling: One surface water sample will be collected from the outfall downstream of the catch basin in the parking lot (shown on **Figure 1**) and analyzed for TCL VOCs, plus 10 TICs (TCL VOCs + 10) – low level.

4.2 Monitoring Well Installations

A total of 12 monitoring wells will be installed during the Phase I RI.

Monitoring Well	Overburden or Bedrock	Estimated Total Depth (feet bgs)	Estimated Depth to Bedrock (feet bgs)	Screen Interval (feet bgs)	Rationale
MW-100-R	Bedrock	55	15	50-55	Vertical delineation at MW-21R

Monitoring Well	Overburden or Bedrock	Estimated Total Depth (feet bgs)	Estimated Depth to Bedrock (feet bgs)	Screen Interval (feet bgs)	Rationale
MW-101-R*	Bedrock – Multi-level wells	55	15	TBD	Vertical delineation at MW-22R
MW-102-R	Bedrock	85	50	80-85	Vertical delineation at MW-10R
MW-103-R	Bedrock	85	50	80-85	Horizontal delineation
MW-104-R	Bedrock	85	45	80-85	Horizontal delineation
MW-105-R*	Bedrock - Multi-level wells	90	50	TBD	Horizontal delineation
MW-106-R	Bedrock	70	35	65-70	Horizontal delineation
MW-107-R*	Bedrock - Multi-level wells	100	60	TBD	Vertical delineation
MW-200-D	Overburden	60	60	50-60	Characterize plume centerline
MW-201-D	Overburden	55	55	45-55	Horizontal delineation
MW-202-D	Overburden	60	60	50-60	Horizontal delineation
MW-203-D	Overburden	60	60	50-60	Characterize plume centerline

Notes:
Final well construction details may be modified based on field conditions and the results of the borehole geophysics and FLUTe hydrogeological characterizations (see Sections 4.3 and 4.4). Maximum anticipated depths are presented.

*Indicates a proposed location for FLUTe Multi-level wells, FLUTe Activated Carbon Technique (FACT) liners and analysis. Final construction details for multi-level wells will be determined based on investigation findings. It is assumed that three wells, each completed at different depths, will be installed for each multi-level well (see Section 4.5).

bgs = below ground surface

TBD = to be determined following borehole geophysics and FLUTe hydrogeological characterizations

Proposed monitoring well locations are shown on **Figure 1**. Final monitoring well construction details will be determined in the field based on field conditions and the results of the borehole geophysics and FLUTe hydrogeological characterizations described in **Sections 4.3** and **4.4**. The boreholes for the groundwater monitoring wells will be advanced to a depth of 5 feet bgs via hand clearing or soft dig methods and then advanced to terminal depth using sonic drilling methods for the overburden wells, and a combination of sonic and air rotary drilling methods for the bedrock wells. Continuous soil cores at 10-foot lengths will be collected during sonic drilling to record observed soil geology/lithology. Drilling activities will be performed by a licensed drilling subcontractor and observed by TRC. During drilling, soil cores, cuttings, and drill rates, will be documented by TRC in a field logbook to develop a boring log that provides depths of permanent steel casings, depth to bedrock, overburden and bedrock lithology, potential fracture (soft rock) zones, and water loss (as applicable).

4.2.1 Deep Overburden Monitoring Wells

Cascade Drilling, L.P. (Cascade) will install deep overburden monitoring wells using sonic drilling methods. A 6X8 sonic sampling system will be advanced to the top of the bedrock (estimated to be between approximately 55 and 60 feet bgs). Soil samples will be collected continuously from ground surface to the top of bedrock using the sonic sampling system to confirm geology/lithology. Soil samples will be screened using a photoionization detector (PID), inspected for indications of contamination (e.g., staining, odors, etc.), and characterized using the Unified Soil Classification System (USCS). Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining observed, soil samples will be collected for laboratory analysis and analyzed for TCL VOC +10 TICs by the NYSDEC call-out laboratory.

Cascade will construct the deep overburden monitoring wells using 2-inch diameter PVC riser and screen inserted through the 8-inch sonic sampling system override casing. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface.

The new overburden monitoring wells will be developed as described in **Section 4.6**. Monitoring wells MW-200-D, MW-201-D, and MW-202-D will be equipped with locking expansion plugs and completed with flush-mounted manholes set in concrete pads. Monitoring well MW-203-D will be completed as an above-ground, steel standpipe set in a concrete pad. Final well construction may be modified based on encountered field conditions.

4.2.2 Bedrock Monitoring Wells

Cascade will drill bedrock monitoring well boreholes using a combination of sonic and air rotary drilling methods. Either 8-inch diameter (for 4-inch diameter bedrock boreholes) or 10-inch diameter (for 6-inch diameter bedrock boreholes) pilot holes will be advanced through the overburden from ground surface to the top of bedrock (estimated to be between approximately 15 and 60 feet bgs) using 6X8 or 8X10 sonic sampling systems. Soil samples will be collected continuously using the sonic sampling systems to confirm geology/lithology. Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.) and characterized using the USCS. Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining observed, soil samples will be collected for laboratory analysis and analyzed for TCL VOC+10 TICs by the NYSDEC call-out laboratory.

After reaching the top of bedrock, air rotary drilling methods will be used to extend the boreholes approximately 5 feet into competent bedrock. Approximate 6-inch or 8-inch diameter steel casings will be installed to stabilize the overburden and allow completion of the bedrock boreholes. The steel casings will be grouted into place prior to further advancement of the bedrock boreholes to limit potential for leakage around the casings. Following the curing period (24 hours), borings of approximately 4-inch or 6-inch diameter will be advanced below the casings using air-rotary drilling methods to completion depth for all bedrock wells.

Limited well development (i.e., sufficient to remove foreign material introduced by drilling and drill cuttings) will be completed on the new boreholes as described in **Section 4.6**. Boreholes for bedrock monitoring wells MW-100-R, MW-102-R, MW-103-R, MW-104-R, and MW-106-R will be equipped with expansion plugs and completed at ground surface with 12-inch diameter, flush-to-grade, protective steel enclosures. Boreholes for bedrock monitoring wells MW-101-R, MW-105-R and MW-107-R will be equipped with expansion plugs and completed 2-foot by 2-foot square steel vaults set in concrete pads, each extending approximately one foot laterally from the vaults in all directions (4-foot by 4-foot area of concrete and vault).

Borehole geophysics and hydrogeological characterizations will be completed on the newly installed boreholes as described in **Sections 4.3** and **4.4** before the second mobilization.

4.2.2.1 Single Screen Wells

Single screen monitoring wells will be installed at MW-100-R, MW-102-R, MW-103-R, MW-104-R, and MW-106-R with the finished protective surface casings and concrete pads in place. Wells will be constructed using 2-inch diameter Schedule 40 PVC riser and screen. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface. The wells will be redeveloped to meet the water quality criteria as described in **Section 4.6**.

4.2.2.2 Multi-level Wells

At total of three multi-level bedrock monitoring wells will be installed as described in **Section 4.5**.

4.3 Borehole Geophysics

Borehole geophysical surveys will be completed at each newly installed bedrock well (MW-100-R, MW-102-R, MW-103-R, MW-104-R, MW-106-R, MW-101-R, MW-105-R, MW-107-R). The downhole geophysical surveys will be performed by HRGS and observed by TRC. The methods used to perform the surveys include caliper, fluid temperature and conductivity (or resistivity), optical and acoustic televiewer, and/or heat-pulse flow meter under ambient and stress/pumping conditions, and are further described in Appendix C. After completing the surveys, a brief memorandum will be prepared summarizing the depths of potential water-bearing fractures at each borehole.

4.4 FLUTe Hydrogeologic Characterization of Newly Installed Bedrock Boreholes

Based on the borehole geophysics described in **Section 4.3**, hydrogeological characterizations of the bedrock boreholes will be performed using FLUTe liners and profiling methods. TRC will subcontract with FLUTe to perform the hydrogeological characterizations of the bedrock boreholes (refer to Appendix D for the procedures to be used). The table below summarizes the proposed FLUTe characterization scope for each bedrock well.

Monitoring Well	Type of Bedrock Well	Blank Liner	NAPL Liner	FACT Liner & FACT Analysis	Transmissivity and Reverse Head Profiles	FLUTe Multi-level Wells
MW-100-R	Single Screen	√	√	-	√	-
MW-102-R	Single Screen	√	√	-	√	-
MW-103-R	Single Screen	√	√	-	√	-
MW-104-R	Single Screen	√	√	-	√	-
MW-106-R	Single Screen	√	√		√	-
MW-101-R	Multi-level	√	√	√	√	√
MW-105-R	Multi-level	√	√	√	√	√
MW-107-R	Multi-level	√	√	√	√	√

4.4.1 Blank Liners

After completing the bedrock boreholes, blank liners will be installed in each open borehole to prevent contamination migration across the borehole and to facilitate the collection of hydrogeological characterization data using FLUTe profiling methods.

4.4.2 NAPL Liners

NAPL liners will be installed along with the blank liners at each borehole to determine if there are zones of NAPL in the bedrock fractures. A NAPL liner is a hydrophobic material that is installed into the borehole and wicks NAPL contacted in the formation into the liner. Upon removal, NAPL can be directly observed in the form of stains or dye displacement on the liner material.

4.4.3 FACT Liners

FACT liners will be added to the blank and NAPL liners installed at MW-101R, MW-105-R, and MW-107R for mapping the dissolved phase contaminant distribution at 1-foot intervals. After two weeks, the NAPL and FACT liners will be retrieved from the boreholes and processed. Stains on the NAPL liners will be documented for their size and location by measuring the stain length and depth with a tape measure. The FACT liners will be cut in equal sections (1-foot lengths) and placed in sample jars for laboratory analysis. Each 1-foot length of FACT liner will be analyzed for TCL VOCs +10 TICs by a NYSDEC call-out laboratory. These analytical results will not be validated.

4.4.4 Transmissivity and Reverse Head Profiles

Transmissivity and reverse head profiling will be performed at all bedrock borehole locations during liner installation and removal. Transmissivity profiling will be performed at each borehole by measuring the descent rate of the everting liner. The flow paths will be measured at a 6-inch resolution providing information on both flow paths and flow rates. Reverse head profiling will be performed by removing (inversion) the blank liner in a stepwise fashion to measure the new equilibrated head value beneath the liner.

Blank liners will be reinstalled in MW-101R, MW-105-R, and MW-107R until multi-level wells are installed as described in **Section 4.5**.

4.4.5 Results Memo

A brief memorandum will be prepared documenting observations and findings from NAPL liners and FACT analysis, and the results of transmissivity and reverse head profiling. This information will serve as the basis for the construction of the multi-level wells described in **Section 4.5**.

4.5 Construction of Multi-level Wells (Water FLUTe)

Multi-level wells will be installed within the bedrock boreholes for MW-101-R, MW-105-R, and MW-107-R using Water FLUTe systems. At each location, up to three separate bedrock zones will be selected for monitoring in consultation with NYSDEC. It is expected that the monitoring zones will range from approximately 5 to 20 feet depending on the density, spacing, and transmissive characteristics of fractures identified during the borehole geophysics and FLUTe hydrogeologic characterizations. The Water FLUTe systems will be pre-configured with separate screens, sample tubing, check valves, and sample ports for each monitoring zone. The Water FLUTe systems will be installed in the bedrock boreholes via eversion, similar to the blank liner installation process. Filter sand, bentonite, and grout will not be used as systems will seal the entire borehole, except for the screen zones to be monitored. Following installation, the components of each system will be tested to confirm the systems are performing according to manufacturer's design specifications.

4.6 Development of Newly Installed Monitoring Wells

Cascade will develop each of the newly installed monitoring wells, and any existing wells identified to need redevelopment during the initial sampling subtask, using surging and pumping techniques. Groundwater quality parameters (e.g., temperature, conductivity, turbidity, oxidation-reduction potential, etc.) will be monitored prior to, during (at an approximate frequency of once per well volume purged), and at the conclusion of development. Development will be considered complete when either turbidity is below 50 nephelometric turbidity units (NTUs), the well purges dry, or 3 well volumes have been removed, whichever occurs first. Purge water will be containerized for off-Site disposal.

4.7 Groundwater Water Level Measurement and Sampling

A minimum of two weeks after well development activities have been completed, water level measurements in all the existing and newly installed monitoring wells will be conducted in accordance with the FAP using an oil-water interface probe. Each monitoring wells will be screened with a PID and gauged for total well depth, depth to water, and depth to NAPL (if present).

One groundwater sample will be collected from each of the newly installed wells (total of 18 samples) following the synoptic water level measurements. Samples will be collected using low-flow sampling techniques. Field data will be recorded in a field logbook. Groundwater samples will be analyzed for TCL VOCs +10 TICs – low level. The sample collected from MW-105R (estimated bedrock plume fringe) will additionally be analyzed for natural attenuation parameters including alkalinity, chloride, dissolved gases (carbon dioxide, ethene, ethane, and methane), dissolved iron, dissolved manganese, sulfate, total dissolved solids, and total organic carbon. TCL VOCs +10 TICs – low level and natural attenuation parameter analyses (except for alkalinity and dissolved gases) will be completed by a NYSDEC call-out laboratory. Natural attenuation parameter analyses for alkalinity and dissolved gases will be completed by a TRC subcontracted laboratory. Purge water will be containerized for off-Site disposal.

4.8 Indoor Air and Sub-Slab Soil Vapor Sampling and Analysis Activities

A total of four sub-slab soil vapor samples and one indoor air (IA) sample will be collected from the basement of the main manufacturing building located on-site. One outdoor/ambient air sample will also be collected (refer to **Figure 1**). These samples will be collected following the completion of the NYSDOH Indoor Air Quality Questionnaire and Building Inventory form included in the FAP, and if possible, following a 30-day shutdown of the SSDSs. These samples will be collected coincidentally over a continuous, 8-hour period. Three of the four sub-slab soil vapor samples will be collected from locations within the basement selected correspondingly to represent conditions beneath each of three unique slab construction areas and will also be biased towards the three existing basement sumps. One additional sub-slab soil vapor sample will be collected at the south end of the building along with a co-located AI sample. One outdoor/ambient air sample will also be collected on the south side of the building.

It is anticipated that access to the building will be coordinated by the NYSDEC and/or the NYSDOH, with assistance from TRC. The SSDSs will be shut down for 30 days prior to sample collection. Samples will be analyzed by a NYSDEC call-out laboratory for VOCs (64 compound list) via USEPA Method TO-15, with Selective Ion Monitoring (SIM). TO-15 with SIM analysis (TO-15 SIM) will be performed on the samples to achieve low level detection limits, in accordance with NYSDOH guidance. TO-15 SIM will provide detection limits of 1.0 micrograms per cubic meter for most analytes. The minimum reporting limit for trichloroethene, cis-1,2-dichloroethene, 1,1-dichcloroethene, carbon tetrachloride, and vinyl chloride will be 0.2 micrograms per cubic meter.

4.9 Land Survey

L.K. McLean Associates, P.C. (LKMA) will survey the locations and elevations (ground surface, top of well casing, top of PVC well riser, and top of protective cover, as applicable) of existing and newly installed monitoring wells. LKMA will permanently mark the measuring point on each the PVC well risers. In addition, the location of stakes, flags, catch basins, and manholes associated with mark outs for the stormwater sewer lines will be surveyed. A survey report, documenting the coordinates/elevations of the newly installed monitoring wells and stormwater sewer line mark outs will be signed and sealed by LKMA and will be provided in the Phase I RI Report.

4.10 Management of Investigation-Derived Waste

IDW is anticipated to include the following: decontamination fluids, well development and purge water, soil and rock drill cuttings, used personal protective equipment (PPE), and disposable sampling equipment. Wash and rinse water used for equipment decontamination, development water, and purge water will be containerized in a closed top frac tank (10,000-gallon capacity). Drill cuttings and other solids will be containerized in a 20 cubic yard roll-off container. Waste characterization sampling and analysis will be performed prior to off-Site disposal. Waste characterization sample analysis will be performed by a NYSDEC call-out laboratory. Used

PPE and disposable sampling equipment will be containerized in DOT-approved 55-gallon drums for off-Site disposal. Materials containerized for off-Site disposal will be temporarily staged at locations on-site that are acceptable to the NYSDEC and the Owner (e.g., parking lot of the main manufacturing facility). Containerized materials will be clearly marked to indicate the contents of the containers, the date of generation, and the material source. IDW will be properly disposed of off-Site.

4.11 Phase I Remedial Investigation Report

The Phase I RI Report will present the results of the initial investigation activities, be prepared in accordance with the applicable provisions of NYSDEC DER-10 and include the following:

- Background information for the Site.
- Characteristics of the area investigated, including physical features, topography, geology and hydrogeology.
- Description of field investigation activities performed.
- Identification of applicable standards, criteria, and guidance (SCGs).
- Investigation, testing/screening, and sampling results including a comparison to SCGs (as applicable).
- Figures showing the Site location, Site features, sample locations, geology, groundwater surface elevations, contaminant distribution, PEJA, etc.
- Identification of known and/or potential contaminant migration pathways and contaminant receptors.
- Update of the CSM.
- Conclusions regarding the significance of RI findings including recommendations for continuation of the investigation activities (i.e., implementation of the Phase II RI) or completion of a FS.
- Supporting documentation (e.g., field forms, photographs, data usability summary reports, etc.) as appendices.
- Project GSR metrics.

5.0 PHASE II REMEDIAL INVESTIGATION ACTIVITIES

After review and acceptance of the Phase I RI Report, Phase II of the RI will be initiated, as required, to further define the horizontal and vertical extent of contamination at the Site. The Phase II RI activities will include the following activities: obtaining permits from the NYSDOT, mobilization, utility locating survey, CAMP implementation, installation and development of up to four downgradient groundwater monitoring wells along the Taconic State Parkway, borehole geophysics, FLUTe hydrogeological characterization, synoptic water elevation measurement and groundwater sampling, data validation and EQuIS submittals, land surveying, IDW management, and preparation of the Phase II RI Report. The exact number, location, depths, and construction details of the downgradient monitoring wells will be based on the results of the Phase I RI.

5.1 General Activities

TRC will prepare for the Phase II RI and coordinate field work with the NYSDOT, as necessary/required (i.e., prepare/submit Highway Work Permit[s] for accessing the TSP ROW for installing and sampling monitoring wells within the TSP ROW and Restricted Vehicle Permit[s]). TRC will coordinate with the NYSDEC call-out laboratory and TRC's utility locating, drilling, borehole geophysical, FLUTe, IDW management, and land surveying subcontractors. TRC will ensure that Cascade contacts UDig NY (or appropriate utility locating service), receives/reviews utility confirmation receipts, and verifies public utility mark-outs prior to intrusive work.

5.1.1 UDig NY and Utility Locating Survey

Prior to intrusive activities, GPRS will conduct a private utility locating survey, as a supplement to the public utility mark outs, to clear proposed soil boring/monitoring well locations (shown on **Figure 1**). This utility survey will be conducted in a consistent manner as described for the Phase I RI field activities above in **Section 4.1.1**.

5.1.2 Video Inspection of Stormwater Sewer Lines

In addition to the work described in **Section 5.1.1**, GPRS will perform a final video inspection of the stormwater sewer lines (labeled 1, 2, and 3 on **Figure 1**) following the completion of the work covered by this Work Plan. This inspection will be performed to identify cracks, breaches, junctions/connections, other significant features, and damage to the sewers, if determined to be necessary by NYSDEC.

5.2 Additional Monitoring Well Installations

Up to four monitoring wells will be installed during the Phase II RI:

Monitoring Well	Overburden or Bedrock	Estimated Total Depth (feet bgs)	Estimated Depth to Bedrock (feet bgs)	Screen Interval (feet bgs)	Rationale
MW-108-R	Bedrock	110	75	100-110	Downgradient center
MW-109-R	Bedrock	110	60	100-110	Downgradient west
MW-110-R	Bedrock	110	60	100-110	Downgradient east
MW-204-D	Overburden	75	75	65-75	Downgradient east

Notes:
Final well construction details may be modified based on field conditions and the results of the borehole geophysics and FLUTe hydrogeological characterizations (see Section 5.3 and 5.4). Maximum anticipated depths are presented.

Preliminary Phase II RI monitoring well locations are shown on **Figure 1**. Final monitoring well construction details will be determined in the field based on field conditions and the results of the borehole geophysics and FLUTe hydrogeological characterizations described in **Section 5.3** and **5.4**. The drilling and documentation of the Phase II RI monitoring wells will be consistent with the manners used for the Phase I RI monitoring wells described above in **Section 4.2**.

5.2.1 Deep Overburden Monitoring Well

One deep overburden monitoring will be installed as part of the Phase II RI activities (MW-204-D). Consistent with the Phase I RI activities (**Section 4.2.1**), this deep overburden monitoring well will be installed using sonic drilling methods. A 6X8 sonic sampling system will be advanced to the top of the bedrock (estimated to be approximately 75 feet bgs). Soil samples will be collected continuously from ground surface to the top of bedrock using the sonic sampling system to confirm geology/lithology. Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.) and characterized using the USCS. Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining, soil samples will be collected for laboratory analysis and analyzed for TCL VOC+10 TICs.

Monitoring well MW-204-D will be constructed using 2-inch diameter PVC riser and screen that will be inserted through the 8-inch sonic sampling system override casing. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface. This well be completed as an above-ground, steel standpipe set in a concrete pad. Final well constructions may be modified based upon encountered field conditions. This well will be developed as described above in **Section 4.6.**

5.2.2 Bedrock Monitoring Wells

Three bedrock monitoring wells will be installed as part of the Phase II RI activities using consistent methodologies as those used for the Phase I RI activities described above in **Section 4.2.2** (single screen wells only). As noted previously, the boreholes will be completed for these bedrock monitoring wells using a combination of sonic and air rotary drilling methods. Eight-inch diameter (for 4-inch diameter bedrock boreholes) pilot holes will be advanced through the overburden from ground surface to the top of bedrock (estimated to be approximately 60 to 75 feet bgs) using a 6X8 sonic sampling system. Soil samples will be collected continuously using the sonic sampling system to confirm geology/lithology. Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.) and characterized using the USCS. Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining, soil samples will be collected for laboratory analysis and analyzed for TCL VOC+10 TICs by the NYSDEC call-out laboratory.

After reaching the top of bedrock, air rotary drilling methods will be used to extend the boreholes approximately 5 feet into competent bedrock. Six-inch diameter steel casings will be installed to stabilize the overburden and allow completion of the bedrock boreholes. The steel casings will be grouted into place prior to further advancement of the bedrock boreholes to limit potential for leakage around the casings. Following the curing period (24 hours), borings of approximately 4-inches in diameter will be advanced below the casings using air-rotary drilling methods to completion depth for the bedrock wells.

Limited well development (i.e., sufficient to remove foreign material introduced by drilling and drill cuttings) will be completed on the new boreholes in general accordance with **Section 4.6.** Boreholes (MW-108-R, MW-109-R and MW-110-R) will be completed at ground surface with 12-inch flush-to-grade protective steel enclosures.

Geophysical investigations and hydrogeological characterizations will be completed on the newly installed boreholes as described in **Sections 5.3** and **5.4** before the second mobilization. During the second mobilization, single screen monitoring wells will be installed at MW-108-R, MW-109-R and MW-110-R with finished protective surface casings and concrete pads in place. Wells will be constructed using 2-inch diameter PVC riser and screen. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface. The wells will be re-developed to meet the water quality criteria as described previously in **Section 4.6.**

5.3 Borehole Geophysics

Borehole geophysical surveys will be completed at each newly installed bedrock borehole (MW-108-R, MW-109-R, and MW-110-R). The downhole geophysical surveys will be performed by HRG (and observed by TRC) using the protocols included in Appendix C. After completing the surveys, a brief memorandum will be prepared summarizing the depths of potential water-bearing fractures at each borehole.

5.4 FLUTe Hydrogeologic Characterization of Newly Installed Bedrock Boreholes

Consistent with the Phase I RI activities described above in **Section 4.4**, following completion of the borehole geophysics, hydrogeological characterizations of the Phase II RI bedrock boreholes will be performed using FLUTe liners and profiling methods (refer to Appendix D). TRC will subcontract with FLUTe to perform the hydrogeological characterizations of the bedrock boreholes as summarized below.

5.4.1 Blank Liners

After completing the bedrock boreholes, blank liners will be installed in each open borehole to prevent contamination migration across the borehole and to facilitate the collection of hydrogeological characterization data using FLUTe profiling methods.

5.4.2 Transmissivity and Reverse Head Profiles

Transmissivity and reverse head profiling will be performed at the bedrock borehole locations. Transmissivity profiling will be performed at each borehole by measuring the descent rate of the everting liner. The flow paths will be measured at a 6-inch resolution providing information on both flow paths and flow rates. Reverse head profiling will be performed by removing (inversion) the blank liner in a stepwise fashion to measure the new equilibrated head value beneath the liner.

Blank liners will be reinstalled in MW-108-R, MW-109-R, and MW-110-R until wells are installed as described in **Section 5.2.2**.

5.4.3 Results Memo

A brief memorandum will be prepared documenting observations and findings from NAPL liners and FACT analysis, and the results of transmissivity and reverse head profiling.

5.5 Development of Newly Installed Monitoring Wells

Following installation of monitoring wells, Cascade will develop each of the newly installed monitoring wells, as described previously above in **Section 4.6**. Purge water will be containerized for off-Site disposal.

5.6 Groundwater Water Level Measurement and Sampling

A minimum of two weeks after well development activities have been completed, water level measurements in the existing and newly installed monitoring wells will be conducted in accordance with the FAP using an electronic water level meter. As part of this subtask, the monitoring wells will be screened with a PID and gauged for total well depth, depth to water and depth to NAPL.

One groundwater sample will be collected from each of the newly installed monitoring wells (total of 4 samples) following the synoptic water level measurements. Samples will be collected using low-flow sampling techniques. Field data will be recorded in a field logbook. Groundwater samples will be analyzed for low-level TCL VOCs +10 TICs. TCL VOCs +10 TICs analysis will be completed by a NYSDEC call-out laboratory.

Following receipt of laboratory analytical data, the ASP-B data deliverable packages will be reviewed by a TRC data validator. Based on the results of the validation, DUSRs will be issued, and the EDDs updated with validated qualifiers, if any. The validated and qualified EDDs, in EQuIS format, will be submitted to NYSDEC, and the results will be provided in the Phase II RI Report.

5.7 Land Survey

LKMA will survey the locations and elevations (ground surface, top of well casing, top of PVC well riser, and top of protective cover, as applicable) of existing and newly installed monitoring wells. LKMA will permanently mark the measuring point on each the PVC well risers. In addition, the location of stakes, flags, catch basins, and manholes associated with mark outs for the stormwater sewer lines will be surveyed. A survey report, documenting the coordinates/elevations of the newly installed monitoring wells will be signed and sealed by LKMA and will be provided in the Phase II RI Report.

5.8 Management of Investigation-Derived Waste

IDW will be managed as described previously in **Section 4.10**.

5.9 Phase II Remedial Investigation Report

The Phase I RI Report will be modified to document and include the results of the Phase II RI activities completed at the Site.

6.0 SCHEDULE

Presented below is a project schedule for implementation of each of the tasks described above. This Schedule is based on NYSDEC Work Plan approval by October 3, 2023. Once the project is underway, this schedule will be updated periodically and summarized in the regular monthly project progress reports during project implementation.

Task Description	Estimated Completion Date
Phase I RI Work Plan	
Approve Phase I RI Work Plan	10/3/2023
Initial Activities	
Subcontracting	10/13/2023
Utility Clearance Sampling of Sump Water and Surface Water	10/18/2023
Inspection of Existing Wells	Completed (8/3/2023)
New Monitoring Well Installations	
Deep Overburden Monitoring Well Borehole Installations	10/25/2023
Bedrock Monitoring Well Installations	11/15/2023
Perform Geophysical Surveys and FLUTe Hydrogeologic Characterizations (2-week turnaround time on data)	12/15/2024
Memo of Results of Borehole Geophysics and FLUTe Characterizations	1/30/2024
Review and Finalize Memo of Results of Borehole Geophysics and FLUTe Characterizations and Bedrock Monitoring Zone Determinations (NYSDEC/TRC)	2/27//2024
Construction of Single-Screened Bedrock Monitoring Wells	3/25/2024
Construction of Multilevel Wells (Water FLUTe System Installations)	4/8/2024
Development of Existing and Newly Installed Deep Overburden and Single-Screen Bedrock Monitoring Wells	4/15/2024
Groundwater Level Measurements and Sampling	
Groundwater Level Measurement (Synoptic) and Sampling of Existing, Newly Installed Deep Overburden, and Bedrock Wells (61 wells)	5/6/2024
Other Activities	
Land Survey Activities	4/22/2024
Indoor Air Sampling (Turn Off Existing SDSS 30 Days Prior)	12/12/2023
Management of Investigation-Derived Wastes	5/17/2024
Laboratory Analyses, Data Validation and EQuIS Submittals	10/18/2024
Phase I RI Report	
Initial Draft Phase I RI Report	1/31/2025
NYSDEC Review of Draft Phase I RI Report	2/28/2025
Final Phase I RI Report	3/21/2025

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(HASP, CAMP, QAPP AND FAP)

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APPENDIX D
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Table 1
New York State Department of Environmental Conservation
Farrand Controls – Site No. 360046
WA No. D009812-30
Proposed Sample Analysis Summary

Task	Sample Type	Sample Matrix	Number of Samples for Analysis	TCL VOCs +10 TICs	TO-15 SIM[1] - VOCs (64 compound list)	Natural Attenuation Parameters[2]	Waste Characterization Parameters[3]
PHASE I REMEDIAL INVESTIGATION SAMPLING AND ANALYSES							
Surface Water & Basement Sump Sampling	Surface Water	Water	1	X	X		
	Sump Water	Water	3				
	Blind Duplicate	Water	1				
	MS/MSD	Water	2				
	Trip Blank	Water	1				
	Equipment Blank	Water	1				
Existing Groundwater Monitoring Well Sampling - All Wells	Groundwater	Water	49	X	X	X (Select Wells Only - 14)	
	Blind Duplicate	Water	3				
	MS/MSD	Water	6				
	Equipment Blank	Water	3				
	Trip Blank	Water	10				
Newly Installed Deep Overburden Groundwater Monitoring Well Installation & Sampling	Groundwater	Water	4	X			
	Soil[4]	Soil[4]	12				
	Blind Duplicate	Water	1				
	Blind Duplicate	Soil	3				
	MS/MSD	Water	1				
	MS/MSD	Soil[4]	6				
	Equipment Blank	Water	1				
	Trip Blank	Water	1				
Newly Installed Bedrock Groundwater Monitoring Well Installation & Sampling	Groundwater	Water	14	X		X (Only MW-105R)	
	Soil[4]	Soil[4]	24				
	FLUTe Liner	Solid	120				
	Blind Duplicate	Water	4				
	Blind Duplicate	Soil[4]	4				
	Blind Duplicate	Solid	5				
	MS/MSD	Water	6				
	MS/MSD	Soil[4]	6				
	MS/MSD	Solid	10				
	Equipment Blank	Water	16				
	Trip Blank	Water	6				
Air/Vapor Sampling	8-hour Composite	Air/Soil Vapor	6		X		
	Blind Duplicate	Air/Soil Vapor	1				
	MS/MSD	Air/Soil Vapor	0				
Investigation-Derived Waste	IDW	Liquid IDW	2				X
	IDW	Solid IDW	2				

Table 1
New York State Department of Environmental Conservation
Farrand Controls – Site No. 360046
WA No. D009812-30
Proposed Sample Analysis Summary

Task	Sample Type	Sample Matrix	Number of Samples for Analysis	TCL VOCs +10 TICs	TO-15 SIM[1] - VOCs (64 compound list)	Natural Attenuation Parameters[2]	Waste Characterization Parameters[3]
PHASE II REMEDIAL INVESTIGATION SAMPLING AND ANALYSES							
Newly Installed Deep Overburden Groundwater Monitoring Well Installation & Sampling	Groundwater	Water	1	X			
	Soil[4]	Soil[4]	3				
	Blind Duplicate	Water	1				
	Blind Duplicate	Soil	1				
	MS/MSD	Water	2				
	MS/MSD	Soil[4]	2				
	Equipment Blank	Water	4				
	Trip Blank	Water	1				
Newly Installed Bedrock Groundwater Monitoring Well Installation & Sampling	Groundwater	Water	3	X			
	Soil[4]	Soil[4]	9				
	Blind Duplicate	Water	2				
	Blind Duplicate	Soil[4]	2				
	MS/MSD	Water	2				
	MS/MSD	Soil[4]	2				
	Equipment Blank	Water	6				
	Trip Blank	Water	2				
Investigation-Derived Waste	IDW	Liquid IDW	1				X
	IDW	Solid IDW	1				
		Total	**376**				

Notes:

[1] - TO-15 SIM signifies USEPA. 1999. "Air Method, Toxic Organics-15 (TO-15): Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition: Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)." EPA 625/R-96/010).

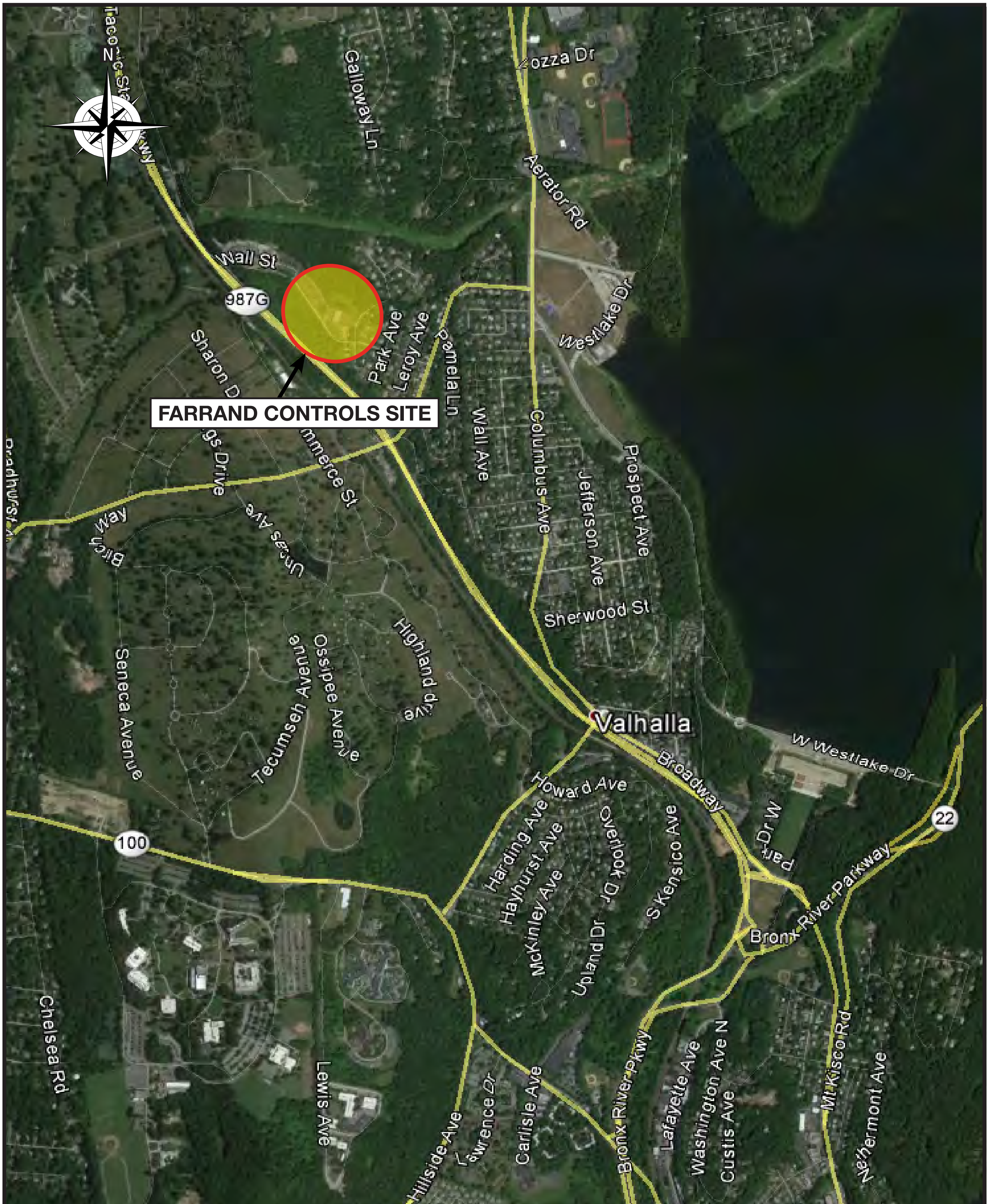
[2] - Natural attenuation parameters include: chloride, dissolved iron, dissolved manganese, sulfate, nitrate, total dissolved solids, and total organic carbon. **NOTE:** Natural attenuation parameter analyses also include alkalinity and dissolved gasses which will be analyzed by a TRC subcontracted laboratory.

[3] - Waste characterization parameters include: TCL VOCs, TCL SVOCs, TCL pesticides, TAL metals, PCBs, TPH DRO/GRO, ignitability, corrosivity, and reactivity. In addition, solid IDW will be analyzed for the full list of Resource Conservation and Recovery Act (RCRA) toxicity constituents by toxicity characteristic leaching procedure (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver), cyanide, and paint filter.

[4] - Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.). In the event elevated PID readings are encountered and/or there is visible staining, soil samples will be collected for laboratory analysis and analyzed for TCL VOC+10 TICs. It is assumed for purposes of this summary that three samples per borehole will be subject to laboratory analyses.

IDW	: Investigation-Derived Waste	TAL	: Target Analyte List
MNA	: Monitored Natural Attenuation	TCL	: Target Compound List
MS/MSD	: Matrix Spike/Matrix Spike Duplicate	TICs	: Tentatively Identified Compounds
PCBs	: Polychlorinated Biphenyls	TPH DRO/GRO	: Total Petroleum Hydrocarbons Diesel- and Gasoline-Range Organics
SVOCs	: Semivolatile Organic Compounds	VOCs	: Volatile Organic Compounds

FIGURES



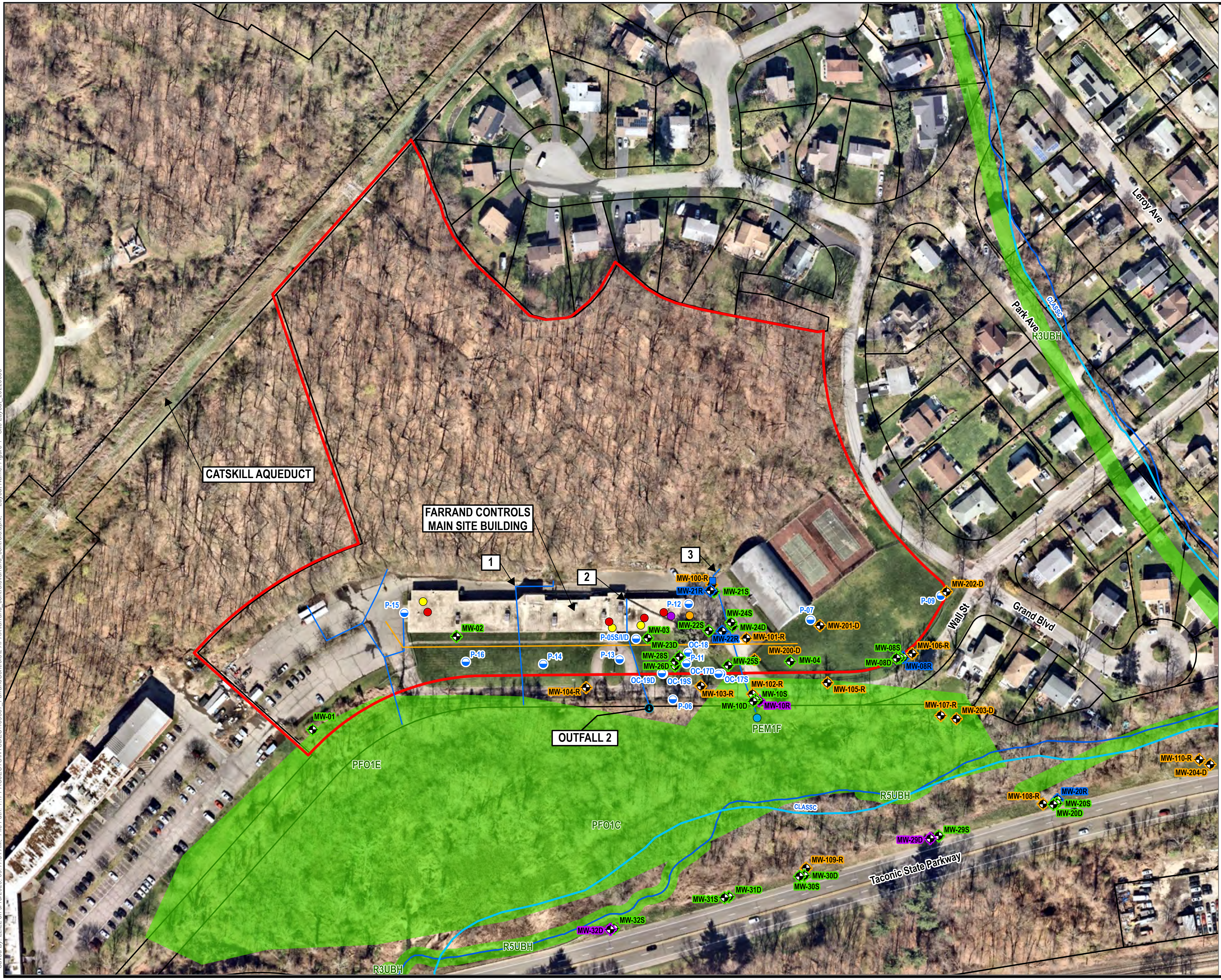
TRC Engineers, Inc.

FARRAND CONTROLS SITE
VALHALLA, NEW YORK

SITE LOCATION MAP

SCALE: NTS

FIGURE 1



LEGEND

- STORMWATER CATCH BASIN
- SUMP
- STORMWATER OUTFALL 2
- PROPOSED SURFACE WATER SAMPLE
- PROPOSED INDOOR AIR SAMPLE
- SUB-SLAB SOIL VAPOR SAMPLE
- OUTDOOR AMBIENT AIR SAMPLE
- BEDROCK MONITORING WELL
- OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- PROPOSED MONITORING WELL
- PIEZOMETER
- APPROXIMATE SANITARY SEWER
- 1,2,3 - PROPOSED STORM SEWER LINE INSPECTION
- NWI WETLANDS
- NYSDEC CLASSIFIED STREAM
- NHD FLOWLINE
- WESTCHESTER COUNTY TAX PARCEL BOUNDARIES
- FARRAND CONTROLS COUNTY TAX PARCEL BOUNDARY

NOTES:

1. LOCATIONS AND DIMENSIONS OF PHYSICAL FEATURES AND BOUNDARIES ARE APPROXIMATE.
2. BASE MAP FROM NEARMAP IMAGERY DATED APRIL 13, 2022.
3. SITE DATA AND FEATURES ARE FROM THE FARRAND CONTROLS SITE ENVIRONMENTAL SAMPLING PROGRAM REPORT BY DVIRKA AND BARTILUCCI CONSULTING ENGINEERS (2015).
4. WELL DESIGNATIONS FOR WELLS SCREENED IN OVERBURDEN, BEDROCK, AND WEATHERED BEDROCK ARE BASED ON TRC'S EVALUATION OF AVAILABLE LOGS. WHERE LOGS ARE NOT AVAILABLE, DESIGNATIONS ARE BASED ON THE FOLLOWING WELL NOMENCLATURE:

   S = SHALLOW OVERBURDEN
   D = DEEP OVERBURDEN
   R = BEDROCK

5. NWI WETLANDS ARE FROM USFWS NWI; NYSDEC CLASSIFIED STREAM IS FROM NYSDEC; NHD FLOWLINE IS FROM USDS NSD.
6. NO NYSDEC WETLANDS EXIST WITHIN MAP EXTENT.
7. SUB-SLAB SOIL VAPOR SAMPLES WILL BE SELECTED IN THE FIELD SUCH TO REPRESENT UNIQUE AREAS OF SLAB CONSTRUCTION AND WILL BE BIASED TOWARDS THE SUMPS.

1:1,800

1" = 150' SHEET SIZE: 11X17L

0 75 150 FEET

PROJECT:
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
FARRAND CONTROLS - SITE NO. 360046
99 WALL STREET
VALHALLA, NEW YORK 10595

TITLE:

SITE LAYOUT MAP

DRAWN BY:	L. LILL	PROJ. NO.:	489357.0000.0000
CHECKED BY:	S. KOTA	FIGURE 2	
APPROVED BY:	J. MAGDA		
DATE:	SEPTEMBER 2023		

TRC

3 Corporate Drive
Suite 202
Clifton Park, NY 12065
Phone: 518.348.1190

FILE: farrand_controls.aprx

Coordinate System: NAD 1983 StatePlane New York East FIPS 3101 Feet; Map Rotation: 57 -- Saved By: LLILL on 9/15/2023, 09:11:34 AM; File Path: T:\1-PROJECTS\NYSDEC\489357_FarrandControls\3-APRX\farrand_controls\farrand_controls.aprx; Layout Name: Figure 1 - Site Layout_20220603

APPENDIX A
GENERIC PLANS
(HASP, CAMP, QAPP AND FAP)

GENERIC HEALTH AND SAFETY PLAN

STANDBY ENGINEERING SERVICES
CONTRACT NO: D009812

Prepared for:

NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, New York 12233

Prepared by:
TRC Engineers, Inc.
1430 Broadway
New York, New York 10018

APRIL 2020

RECORD OF REVISIONS

Revision No.	Revision Date	Summary of Revision	Modified by
0	4/1/2020	New document	J. King

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SECTION PAGE

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

This Generic Health and Safety Plan (HASP) has been developed for use on work assignments issued to TRC Engineers, Inc. (TRC) under New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation (DER), Standby Engineering Services Contract No. D009812. Compliance with this Generic HASP, and associated documents, is required for all TRC personnel entering NYSDEC project sites and/or conducting NYSDEC project field work. This Generic HASP has been prepared to meet the requirements specified in the following regulations, standards, guidance, policies, etc.:

- 29 Code of Federal Regulations (CFR), Chapter XVII Occupational Safety and Health Administration (OSHA), Part 1910 Occupational Safety and Health Standards, Section 1910.120 Hazardous Waste Operations and Emergency Response (HAZWOPER)
- 29 CFR Part 1926 – OSHA Safety and Health Regulations for Construction
- National Institute for Occupational Safety and Health (NIOSH) 85-115 – Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities
- NYSDEC, DER Standby Engineering Services Contract No. D009812
- United States Environmental Protection Agency (USEPA) Standard Operating Safety Guides
- USEPA Superfund Amendments and Reauthorization Act (SARA) Title 1 Section 126 – Health and Safety Audit Guidelines
- TRC Health and Safety Management System

To ensure the safety of its employees, TRC maintains a Health and Safety Management System (HSMS), which consists of procedures and programs detailing employee responsibilities and safe work practices. TRC HSMS procedures and programs applicable to NYSDEC Standby Engineering Services Contract D009812 have been included in this Generic HASP as **Appendix A**. These procedures and programs will be followed by TRC personnel during field activities. A listing of the procedures and programs within **Appendix A** is presented in **Table 1** below:

Table 1: TRC HSMS Procedures and Programs within Appendix A

TRC Procedure / Program No.	Procedure / Program Title
Engineer Roles and Responsibilities	
PR02	Hazard Identification, Risk Assessment, and Determining Controls Procedure
PR05	Roles and Responsibilities Procedure
PR06	Competence, Training, and Awareness Procedure

Table 1: TRC HSMS Procedures and Programs within Appendix A

TRC Procedure / Program No.	Procedure / Program Title
CP001	Hazard Communication Program
Applicable Safety Practices	
CP004	Electrical Safety Program
CP008	Confined Space Entry Program
CP011	Heat Stress Prevention Program
CP012	Cold Stress / Cold Weather Safety Program
CP014	Radiation Safety Program
CP024	Excavation and Trench
CP030	Signs, Signals, and Barricades Compliance Program
CP052	Pandemic Preparedness Program
Decontamination Procedures	
ECR010	Equipment Decontamination
Personal Protective Equipment Programs	
CP003	Personal Protective Equipment Program
CP007	Respiratory Protection Program
CP013	Hearing Conservation Program
Employee Training and Medical Surveillance Procedures	
CP009	Health and Safety Training Program
CP015	Behavior-Based Safety Program
CP027	Fitness for Duty Program
Accident Prevention and Contingency Plans	
PR011	Incident Investigation, Nonconformance, and Corrective and Preventative Action Procedure
CP010	First Aid / CPR / AED Bloodborne Pathogens Exposure Control Plan
CP019	TRC Incident Response and Lessons Learned Program
CP046	Spill Prevention/Response Program

1.1 Objective and Scope of the Generic HASP

This Generic HASP, and associated documents, establish the on-site health and safety procedures and programs that are necessary to ensure the health and safety of TRC personnel entering NYSDEC project sites and/or conducting NYSDEC project field work. Specifically, this Generic HASP addresses the following general health and safety items specified in Standby Engineering Services Contract No. D009812:

- Responsibilities of Consultant (Appendix A, PR05 and PR06)
- Risk Analysis (Section 2.0)
- Safety Practices (Appendix A)
- Personal Protective Equipment (Appendix A, CP003)
- Site Control Procedures (Appendix A, CP030)
- Work Zones (Section 3.0)
- Decontamination Procedures (Appendix A, ECR 010)
- Site Monitoring Procedures (Section 4.0)
- Employee Training Procedures (Appendix A, CP009 and CP015)
- Medical Surveillance Procedures (Appendix A, CP027)
- Accident Prevention and Contingency Plans (Appendix A, PR011, CP019, and CP046)
- Additional information required to comply with Federal, State, and local codes, rules, and regulations (Generic HASP and associated documents)

Due to the variety of project sites and work activities associated with the contract, site-specific information (i.e., unique health and safety hazards, job safety analyses, project-specific precautions and protocols, etc.) will be included in a site-specific HASP developed for each work assignment issuance under the contract. The Generic and site-specific HASPs will establish the requirements for health and safety training, supervision, air monitoring, medical monitoring, personal protective equipment (PPE), site controls, safe work practices and proper decontamination at each site, as needed. The Generic and site-specific HASPs will be adhered to by all TRC personnel entering NYSDEC project sites and/or conducting NYSDEC project field work.

1.2 Generic HASP Review and Amendments

This Generic HASP will be reviewed periodically for compliance with applicable laws, rules, regulations, etc. and applicability to project sites, field activities, and work assignment issuances under the contract. The individual responsible for reviewing the Generic HASP will be the TRC Health and Safety Officer (HSO) who is a qualified and experienced health and safety professional, knowledgeable of environmental issues and has the authority to commit resources and implement revisions/changes to the Generic HASP, where necessary. The following components will be reviewed periodically:

- Generic HASP language
- Applicable regulations, standards, guidance, policies, etc.
- TRC HSMS Procedures and Programs
- Site-specific HASP template

The Generic HASP will undergo a complete review (and/or amendment, as appropriate) at the following frequencies:

- Annually
- Change in Federal, State, or local regulations which effect the health and safety and/or work practices of TRC personnel
- Following any OSHA recordable injury or illness as defined by 29 CFR Part 1904
- Following any incident resulting in property damage or loss and/or an environmental release
- Upon NYSDEC request

Generic HASP modifications (as appropriate) will be made within 60 calendar days after discovery, observation, or event requiring the review. If revisions and/or changes are made to the Generic HASP, they will be described in the Record of Revisions (page i of this Generic HASP) and provided to the NYSDEC for review and approval. Implementation of the new or modified health and safety procedures will be initiated immediately upon NYSDEC approval.

To ensure that appropriate activities are taken in response to the review process, each Generic HASP review will be logged and tracked on the form included in **Appendix B**.

2.0 RISK ANALYSIS AND SITE-SPECIFIC HASPS

At the onset of each work assignment, field work involving TRC employees will be evaluated by the assigned TRC Project Manager and HSO to identify and assess any potential site-specific hazards.

The risk analysis process will begin by collecting and reviewing all available site-specific information, including but not limited to the following:

- Information provided by NYSDEC regarding physical site characteristics and the known or suspected use, storage, and/or disposal of hazardous substances at the site and adjacent properties.
- Information obtained from NYSDEC's Environmental Remediation and Spill Incidents Databases and DECinfo Locator Map.
- Safety data sheets (SDSs) and other technical information regarding chemical substances, either known or suspected, to be present at the project site.
- Maps, sketches, drawings, or photographs of site conditions.
- Available historical data collected by TRC, the NYSDEC, the potential responsible party (PRP), and/or other organizations during prior site work.
- The type of work planned for TRC personnel and the associated potential hazards.
- Historical incidents associated with the project site or similar types of field work.
- Applicable Federal, State, and local health and safety regulatory requirements.

Due to the nature of work and types of project sites under this contract, it is anticipated that all on-site work will require development of a site-specific HASP. The site-specific HASP template is provided in **Appendix C**. The site-specific HASP will be prepared by TRC prior to commencement of field activities and a copy of the document will be provided to the NYSDEC Project Manager upon completion.

It is anticipated that the standard operating procedures (SOPs) detailed in TRC's Generic Field Activities Plan (FAP) will be utilized for all work practices. If site-specific activities require additional or alternate procedures, TRC will assess the task hazards and controls using job safety analyses (JSAs). The individual JSAs will be maintained within the site-specific HASP.

The site-specific HASP and all related and/or relevant documentation will be maintained at the project site by TRC personnel and available for the duration of field activities.

3.0 WORK ZONES

Field activities may be subject to work zone partitioning. The Restricted Zone (RZ) will be identified as the area within which all project operations take place and only authorized personnel are allowed. The RZ will be divided into three work areas: the Exclusion Zone (EZ), the Contaminant Reduction Zone (CRZ), and the Support Zone (SZ). Typically, a 5-foot wide (or other distance as determined by the HSO) strip of land bordering the EZ is considered the CRZ. Additionally, a specially demarcated area that connects the decontamination area to the CRZ is treated as an extension of the CRZ. All other areas inside the RZ that are not an active EZs or CRZs are treated as EZs.

3.1 Exclusion Zone

The EZ includes the intrusive activities area, isolates the potential contaminant generation area, and restricts (to the extent possible) the spread of contamination from active work zones to support zones and off-site locations. The EZ will be demarcated by the "Hot Line" (e.g., tape, rope, physical barriers, etc.). Personnel entering the EZ must:

- Enter through a controlled access point (the CRZ)
- Wear the prescribed level of PPE
- Be authorized to enter the EZ

Personnel, equipment, and materials exiting the EZ will be subject to decontamination in the CRZ. Equipment and materials will be decontaminated at temporarily constructed decontamination areas.

No personnel will be positioned downwind of the EZ during intrusive activities and sampling, if possible.

3.2 Contaminant Reduction Zone

The extent and configuration of the CRZ will be at the discretion of the HSO and/or on-site TRC field representative. Certain safety equipment (e.g., emergency eye wash, fire extinguisher, and first aid kit) will be located near the sampling location.

The PPE level to be used for decontamination will typically be Level D. If more protective PPE levels are warranted, the TRC Project Manager and HSO will conduct a hazard analysis to make the determination based on air monitoring readings and visual inspection of personnel and equipment operations in the EZ. Equipment operators (e.g., truck drivers) physically performing tasks outside of the EZ may be exempt from this requirement as approved by the TRC HSO. Personnel will remove all PPE in the CRZ.

3.3 Support Zone

Equipment and materials, paperwork, SDSs, and emergency and communications equipment, will be stored in the SZ.

4.0 SITE MONITORING PROCEDURES

In order to protect site workers from harmful exposures to site-related contaminants, airborne toxic materials, potentially explosive gases, excessively cold conditions, etc., regular environmental and worker monitoring will be performed. Additionally, community monitoring will also be performed to protect third parties and the general public from harmful exposures to site-related contaminants and/or dust resulting from site activities.

4.1 Air Monitoring

Particular work phases will require the use of specific air monitoring equipment to detect relative contaminant levels or identify unknown environments.

All air monitoring will be conducted by the TRC site personnel for the express purpose of safeguarding the health and welfare of site workers and the general public.

4.1.1 Air Monitoring Instrumentation

Specific to each work assignment, on-site air monitoring will be performed using one or more of the following direct reading instruments:

- Portable photoionization detector (PID) or flame ionization detector (FID) to determine the presence of organic volatile vapors.
- Portable multi-gas monitor (4-gas meter) for lower explosive limit (LEL), hydrogen sulfide (H_2S), carbon monoxide (CO), and oxygen (O^2) for the determination of hazardous conditions. Under no circumstances will confined spaces be entered unless discussed with a TRC confined space subject matter expert. The site-specific HASP will incorporate any additional safety requirements and document that all personnel are trained appropriately to enter confined spaces.
- Colorimetric detector tubes for detecting specific contaminants.
- Respirable dust monitor(s) to monitor airborne particulate emissions.
- Radiation detector for detecting radiological contamination (if appropriate).

All monitoring and surveillance equipment will be operated, maintained, and calibrated each working day in accordance with the manufacturer's instructions and quality assurance procedures. Continuous or periodic monitoring will be conducted by trained TRC personnel depending on the field activities and potential hazards. Should monitoring indicate a high hazard potential, the TRC HSO or on-site personnel will review the results and halt work, if appropriate.

Daily air monitoring forms, daily log book entries and instrument data collection applications will be used to record monitoring data. Instrument calibration forms will be used to document any calibrations performed. These forms are provided in and will be maintained within the site-specific HASP (**Appendix C**) for the project's duration.

Monitoring and surveillance equipment can be impacted by cold or wet weather, communication transmissions, and possibly high voltage electrical transmission wires and other interferences. Any unusual meter responses will be noted on the air monitoring forms and daily log book entries and a diagnosis of the potential influencing factors made to determine and eliminate the cause.

4.1.2 Community Air Monitoring Plan

During ground intrusive activities, air monitoring for volatile organic compounds (VOCs) and particulate matter will be accomplished at the upwind and downwind EZ perimeter to document real time contaminant and dust levels potentially migrating away from the work area. All Community Air Monitoring Plan (CAMP) activities, response levels, and actions will be in accordance with requirements of NYSDEC DER-10, Appendices 1A and 1B, New York State Department of Health (NYSDOH) Generic CAMP and Fugitive Dust and Particulate Monitoring, respectively. Copies of NYSDEC DER-10 Appendices 1A and 1B are provided in **Appendix D**.

The following will be used as a general guide for the number of CAMP stations to be used at a project site based on the type and extent of ground intrusive activities:

- Drilling/Direct Push Activities – 1 upwind and 1 downwind
- Test Pits/Small Exploratory Excavations – 1 upwind and 2 downwind
- Site Clearing/Remedial Excavations/Treatment Activities – 1 upwind and 3 downwind
- Additional configurations of upwind and downwind stations as needed based upon field activities, potential hazards, site conditions/setting and/or NYSDEC/NYSDOH request

In addition to continuous monitoring during ground intrusive activities, periodic monitoring for VOCs will also be conducted during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from monitoring wells.

4.2 Off-Site Migration Procedures

Procedures and protocols practiced by on-site workers will aid in preventing any potential adverse conditions with respect to areas adjacent to the site. Pre-planning with first responders and emergency services will be completed, as needed, prior to the start of work to ensure a coordinated, rapid and safe response in the unlikely event of a major release. The following notifications and procedures will assist in eliminating or minimizing the potential for off-site migration of contaminated media:

1. Notifications to first responders and emergency services advising them of the planned remedial investigation/cleanup activities and schedule of on-site events, including a site visit (as necessary) to discuss site conditions, contaminants of concern, potential site hazards, and emergency response procedures.
2. Immediate notification of the NYSDEC, NYSDOH, local officials, and emergency services in the event of a threatening hazardous condition that may affect the health and safety of on-site workers and the surrounding community.
3. Decontamination procedures for equipment to prevent off-site migration of contaminants.
4. Use of CAMP air monitoring equipment to monitor for potential off-site contaminant migration.
5. Implementation of dust control measures, such as wetting down the ground surface or using clean cover material to suppress dust in the event that work area dust levels are exceeded.
6. Use of liquid absorbents, pads, booms, berms, etc. to prevent and contain the flow of liquids.
7. Implementation of soil erosion and sediment control practices/measures.

General visual observations will be made during ground intrusive activities to identify the potential for airborne releases (e.g., vapors, aerosols, etc.), including but not limited to color changes in excavated material/drill cuttings, evidence of grossly-impacted material, presence of buried drums/tanks/containers, changes to the surface appearance of contact equipment, etc. Should such conditions be noticed or encountered, work will be halted, and the area evacuated until such time that the appropriate personnel can be contacted and specific procedures for characterizing and handling the hazard can be developed.

Appendix A
TRC Health and Safety Management System Procedures and Programs

1. PURPOSE

The purpose of this procedure is to establish the process and responsibilities related to identifying hazards, analyzing the risk(s), and ensuring effective controls are implemented to minimize the risk of injury or illness to people.

2. SCOPE

This procedure applies to all field work (i.e., project sites) and office locations.

3. DEFINITIONS

Hazard: A source, situation or act that has the potential to cause harm to a person.

Incident: A work-related event in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.

Inherent Risk: The level of risk taking into account existing control measures (i.e., prior to any additional control measures being implemented).

Residual Risk: A level of risk remaining after additional control measures have been implemented.

Risk: The combination of the likelihood of an occurrence of a hazardous event or exposure(s), and the severity of injury or ill health that can be caused by the event or exposure(s).

Risk Assessment: The process of evaluating the risk(s) arising from a hazard, taking into account the adequacy of any existing controls, and deciding whether or not the risk is acceptable.

Significant Incident: Any injury defined by Occupational Safety and Health Administration (OSHA) as "recordable", or any significant near miss that could have resulted a recordable injury.

Significant Hazards: Hazards that without consideration of controls, have the greatest potential to cause serious injury to persons or regulatory violations.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Developing and communicating the process for identifying and controlling hazards for TRC's field work and office locations to Project Managers and Supervisors.
- Providing training to affected personnel on this procedure.

4.2 Project Managers are responsible for understanding and following the hazard identification process for field work and implementing safety precautions necessary for adequately controlling workplace hazards.

4.3 Office Safety Coordinators are responsible for facilitating the Office Safety Inspection Program for their assigned offices.

4.4 Employees are responsible for participating in the hazard identification process associated with their field work and/or office location.

5. PROCEDURE

5.1 TRC employees perform work at various office locations and client sites that involve a wide range of hazards. Because of this diversity, TRC maintains two separate programs for identifying and controlling workplace hazards:

- For field work, TRC utilizes the Risk Analysis/Site-Specific Health and Safety Plan (HASP) Program (CP002) to identify and control hazards.
- For office locations, TRC utilizes the Office Safety Inspection Program (CP020).

5.2 The Site-Specific HASP includes a process for identifying and controlling hazards that could be encountered during field work. The Site-Specific HASP is required for all field work that is has medium or high inherent risk. Field work that is considered low risk (i.e., working inside an office building, touring a client’s manufacturing facility, etc.) will not require a Site-Specific HASP.

5.3 Hazards associated with office work will be primarily identified and controlled using the Office Safety Inspection program.

5.4 Both hazard assessment processes must consider normal and abnormal operating conditions, including start-up, shut-down, maintenance, and potential emergency situations.

5.5 Every health and safety hazard has an inherent risk and residual risk. The inherent risk (without considering controls), and the residual risk (considering existing controls) will be evaluated by assessing the frequency of exposure, the consequence of the outcome, and the likelihood of the consequence occurring, with regard to harming people.

5.6 Project Managers are responsible for ensuring that adequate controls are implemented to reduce the risk of injury or illness to an acceptable level.

5.7 Hazards will be reassessed when work conditions change significantly from plan, in the event of an incident (i.e., near miss or injury), or based on concern of an employee, contractor, or client.

6. RECORDS

Completed project Site-Specific HASPs

Completed Office Safety Inspection Checklists

7. REFERENCES/RELATED DOCUMENTATION

PR08 – Operational Control Procedure

CP002 – Risk Analysis/Site-Specific Health and Safety Plan Program

CP020 – TRC Office Safety Program

1. PURPOSE

The purpose of this procedure is to outline the roles and responsibilities for all personnel within the scope of TRC's Health and Safety Management System.

2. SCOPE

This procedure applies to all TRC employees and TRC managed project sites.

3. DEFINITIONS

Hazard: A source, situation or act that has the potential to cause harm to a person.

Incident: A work-related event in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.

Interested Party: A person or group, inside or outside the workplace concerned with or affected by the Health and Safety performance of the company.

Legal and Other Requirements: Laws, acts, legislation, regulation (local, state, federal, region), codes, standards, and other requirements such as client requirements, Company policies, and voluntary commitments made by TRC.

Health and Safety Network: TRC staff who are assigned full-time or part-time safety roles as listed in the TRC Safety Organization Chart.

4. RESPONSIBILITIES

4.1 The Chief Risk Officer is responsible for:

- Communicating matters of risk associated with Health and Safety to TRC Executives and Managers to promote a culture of risk awareness.
- Actively participating on the Executive Safety Council.

4.2 The National Safety Director is responsible for the following:

- Defining, documenting and communicating roles and responsibilities associated with the Health and Safety Management System to affected personnel.
- Ensuring that a current copy of the Health and Safety Management System procedures and associated documents are maintained on TRC's network.
- Promoting safety awareness by routinely communicating health and safety information to the organization. Relevant topics include recent safety incidents, new or revised safety procedures or programs, status of TRC's safety performance, etc.
- Facilitating the Executive Safety Council and maintaining records of the meetings.
- Maintaining TRC's Health and Safety Management System and making it accessible to TRC employees and other interested parties.

4.3 The Executive Safety Council is responsible for the following:

- Meeting routinely to discuss current topics related to TRC's health and safety performance. Topics could include the following:
  - Recent incidents, root causes and corrective actions involving TRC personnel or projects;
  - Status of health and safety improvement programs; new or proposed legal and other requirements that could apply to TRC;
  - Methods of continually improving TRC's safety performance;
  - Best industry practices.
- Working with the National Safety Director to develop TRC's Health and Safety objectives and targets, and developing the associated Safety improvement programs.

4.4 The Senior Management Team is responsible for:

- Providing the resources necessary for implementing and maintaining TRC's Health and Safety Management System.

4.5 The Corporate Safety Compliance Manager is responsible for the following:

- Providing health and safety technical advice to the National Safety Director on health and safety regulations (i.e., interpretation, recordkeeping requirements, applicability, etc.).
- Reviewing incident reports with the National Safety Director to determine if the injuries or illnesses meet OSHA's recordkeeping criteria.
- Assisting Project Managers and members of TRC's Health and Safety Network with identifying applicable health and safety standards and evaluating compliance with the standards.

4.6 The Corporate Safety Manager is responsible for the following:

- Oversight and management of the TRC Safety Service Desk;
- Assisting the National Safety Director in the management of TRC's Subcontractor Management Program;
- Managing TRC's safety performance tracking system including, entering incident and near miss data, compiling company Safety information and developing metrics reports to review with the National Safety Director;
- Updating internet-based contractor management programs (e.g., PICS, ISNetworld, etc.) and communicating client-specific health and safety requirements to the appropriate Project Managers;
- Assisting Office Safety Coordinators in the development of Site-Specific Health and Safety Plans (HASPs).

4.7 TRC's Legal Department is responsible for facilitating the response to regulatory agencies on legal matters related to Health and Safety.

4.8 Sector Safety Leaders are responsible for the following:

- Providing safety guidance and assistance to the Practices within their respective Sector.
- Communicating with Practice Leaders regarding:
  - The investigation of work-related incidents and the development of corrective actions;
  - Initiatives of the Executive Safety Council;
  - Changes to TRC's Health and Safety Management System.

4.9 Project Managers are responsible for the following:

- Managing projects in accordance with TRC's Health and Safety Management System.
- Consulting with a member of TRC's Health and Safety Network on Safety issues such as Health and Safety training requirements and determining which OSHA standards are applicable to the project.
- Communicating TRC and Client requirements to project employees and Subcontractors.

4.10 Office Safety Coordinators are responsible for:

- Periodically reviewing the Emergency Action Plans for their assigned offices;
- Conducting and documenting Office Safety Inspections and forwarding results to the National Safety Director;
- Ordering necessary Personal Protective Equipment (PPE) for office personnel;
- Communicating relevant safety information to office personnel during meetings, conference calls, and e-mails;
- Assisting Project Managers with developing Site-Specific HASPs;
- Performing safety observations and providing feedback to employees and management;
- Providing safety on-boarding (safety orientation) to new employees.

4.11 Supervisors:

- Communicating roles and responsibilities related to TRC's Health and Safety Management System to supervised employees and personnel working on behalf of TRC.
- Actively participating in incident investigations and implementing associated corrective actions.
- Promoting a proactive safety culture by including health and safety topics in meetings and encouraging employees to report near misses.

4.12 TRC employees are responsible for the following:

- Stopping work upon noticing unsafe acts and conditions, and reporting these conditions to Supervision immediately.
- Understanding and complying with TRC's health and safety procedures and compliance programs.
- Completing required training in accordance with TRC's Health and Safety Management System.
- Complying with the health and safety compliance requirements identified in the Health and Safety Management System.

5. PROCEDURE

5.1 The National Safety Director, in consultation with the Executive Safety Council, will define and document roles and responsibilities associated with TRC's Health and Safety Management System:

- Health and safety roles and responsibilities will be communicated to employees through various methods which could include: roles descriptions, established safety programs and procedures, project HASPs, and e-mail communications.

5.2 Project Managers will communicate roles and responsibilities associated with field work, including client-specific requirements, to project personnel throughout the duration of the project.

5.3 Supervisors will consider roles and responsibilities related to health and safety in employees' annual performance reviews.

6. REFERENCES/RELATED DOCUMENTATION

PR06 Competence, Training and Awareness

1. PURPOSE

The purpose of this procedure is to outline the responsibilities and the process for educating TRC personnel in the relevant Health and Safety topics to reduce the risk of work-related injuries, illnesses and incidents.

This procedure also establishes the process for confirming that Subcontractors working on TRC-managed projects have been provided the applicable Health and Safety training.

2. SCOPE

This procedure applies to all TRC employees and subcontractors working on behalf of TRC.

3. DEFINITIONS

OSHA: Occupational Safety and Health Administration

Hazard: A source, situation or act that has the potential to cause harm to a person.

Incident: A work-related event in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Identifying mandatory health and safety training courses for TRC personnel based on regulatory requirements and roles.
- Working with the Training and Development Coordinator to make health and safety training materials and courses available to TRC personnel.

4.2 The Training and Development Coordinator is responsible for the following:

- Maintaining the health and safety training courses on the TRC Safety Academy and other training programs utilized by TRC.
- Identifying training resources for health and safety topics that are not available on TRC Safety Academy.

4.3 The Corporate Safety Compliance Manager is responsible for the following:

- Providing technical advice to the National Safety Director and the Training and Development Coordinator on health and safety training requirements (i.e., identifying regulatory required training, evaluating content to meet compliance requirements, etc.).

4.4 The Executive Safety Council is responsible for the following:

- Evaluating the effectiveness of this procedure based on reported incidents, client and employee feedback, compliance evaluations, and field observations.

4.5 The Corporate Safety Manager is responsible for the following:

- Communicating TRC's health and safety training requirements to Subcontractors through Internet-based contractor management programs (e.g., PICS, ISNetworld, etc.).
- Providing health and safety training information (i.e., training records, training course titles, frequency of training, etc.) related to TRC employees to clients as requested.

4.6 Project Managers are responsible for the following:

- Identifying the health and safety training based on employee roles and responsibilities, legal and other requirements, and TRC's Health and Safety Management System.
- Confirming that employees participating in field work are current with health and safety training that is applicable to their field work.
- Evaluating the competency of TRC employees and Subcontractors performing field work through discussion and field observations.
- Communicating the need for additional training or remedial training to the appropriate TRC Supervisors and Subcontractor representatives, based on field observations and reports of incidents.

4.7 Supervisors are responsible for the following:

- Communicating with the National Safety Director and the Training and Development Coordinator to identify the required health and safety training for employees under their supervision.
- Evaluating the competency of TRC employees and Subcontractors performing field work through discussion and field observations.
- Assigning additional training or remedial training to employees based on job performance, employee concerns, and incident reports.

4.8 Office Safety Coordinators are responsible for the following:

- Facilitating the new hire safety orientation training for new hire employees.
- Assisting Supervisors in communicating health and safety training requirements to employees.

4.9 Employees are responsible for the following:

- Assisting their direct Supervisor and Project Managers in identifying applicable health and safety training based on job duties and regulatory requirements.
- Completing all assigned health and safety training.
- Communicating the need for additional safety training based on new types of field work, changes in role, or unclear expectations.

5. PROCEDURE

5.1 Health and Safety Training Plan:

- Supervisors will identify initial health and safety training requirements for new employees under their direct supervision, based on job expectations, legal and other requirements, and client requirements:
  - Health and safety training needs will be documented for each TRC employee in the Health and Safety Training Checklist (CP009.1).
  - The Health and Safety Training Map (CP009.2) will be used as a reference document to identify training topics, applicability to the employees' job functions and frequency of training.
- Completed Health and Safety Training Profiles will be forwarded to the Training and Development Coordinator by the employee's Supervisor, and will be used to assign required training courses in the TRC Safety Academy.
- Health and safety training profiles will be reviewed and updated by Supervisors on an annual basis for all employees as well as whenever employees' job assignments are reassigned.

5.2 Training Methods:

- Health and safety courses will be evaluated by the National Safety Director and the Corporate Safety Compliance Manager to confirm the material meets TRC's expectations and confirms to legal and other requirements.
- TRC provides both classroom training, on-line training, and on-the-job training. Classroom training and certification is conducted by designated TRC trainers or outsourced certified safety training companies.
- Health and safety training can be delivered to employees by a variety of methods including computer-based, instructor led, and on-the-job meetings (e.g., tailboard meetings).

5.3 Training Frequency:

- TRC employees will be provided new hire safety orientation within the first week of employment:
    - New hire safety orientation must include the following topics, at a minimum:
        - TRC's Environmental, Health and Safety Policy.
        - Hazard Communication.
        - Emergency Action Plan.
        - Procedure for reporting hazards and work related injuries.
        - Overview of TRC's Health and Safety Management System.
- Prior to performing tasks, employees must successfully complete all required health and safety training as defined on the CP009.1 Health and Safety Training Plan.

5.4 Documentation:

- Documentation for all required training will be forwarded to the Training and Development Coordinator who will retain the records.
    - Training records must include the following criteria, at a minimum:
        - Training date.
        - Instructor and Student(s) names.
        - Training course title.
        - Key training topics.

6. RECORDS

Employee Training Records (TRC Safety Academy)

7. REFERENCES/ RELATED DOCUMENTATION

CP009.1 – Health and Safety Training Checklist

CP009.2 – Health and Safety Training Map

1. PURPOSE

The purpose of the Hazard Communication Program is to ensure that the hazards associated with hazardous chemicals used or stored at TRC's office locations and project sites are classified and the information concerning the chemical hazards is communicated to employees so adequate precautions can be taken. This program outlines the responsibilities and procedures for managing the Hazard Communication Program at TRC office locations and project sites.

2. SCOPE

This procedure applies to all offices and project sites where hazardous chemicals are used or stored.

3. DEFINITIONS

<u>Hazardous chemical</u>: means any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

<u>Label</u>: means an appropriate group of written, printed or graphic information elements concerning a hazardous chemical that is affixed to, printed on, or attached, to the immediate container of a hazardous chemical, or to the outside packaging.

<u>Substance</u>: means chemical elements and their compounds in the natural state or obtained by any production process, including any additive necessary to preserve the stability of the product and any impurities deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Implement this compliance program throughout TRC.
- Make hazard communication training programs available to all TRC employees.

4.2 Office Safety Coordinators are responsible for the following:

- Communicate the requirements of this program to office personnel.
- Maintain a current inventory of hazardous substances for each office location and the corresponding Safety Data Sheets (SDSs) (see Form CP001.1- Hazardous Substance Inventory).
- Periodically inspect the workplace to confirm chemical containers are properly labeled.

4.3 Project Managers are responsible for the following:

- Communicate the requirements of this program (i.e., container labeling, SDS access, and training) to TRC field personnel and affected subcontractors.

4.4 Employees are responsible for the following:

- Complete the training required by this program.
- Review SDSs for hazardous substances associated with their work.
- Following the safety precautions listed in SDSs, TRC's safety programs, sites-specific Health and Safety Plans (HASPs), and training material.

5. PROCEDURES

5.1 Hazardous Substance Inventory:

- An inventory of all hazardous substances stored or used in the workplace shall be maintained by the Office Safety Coordinator (OSC) at each office location. See Form CP001.1 for a Hazardous Substance Inventory.
- An inventory of hazardous substances used or stored at project sites will be listed in the site-specific HASP. This inventory and associated SDSs will be offered to affected contractors working on the project site.

5.2 Container Labeling:

5.2.1 Labels on shipped containers (i.e., receiving new product) should contain the following criteria (**note:** this is a requirement after Dec 1, 2015):

- Product identifier.
- Signal word.
- Hazard statement.
- Pictogram.
- Precautionary statement.
- Name, address, and telephone number of the chemical manufacturer.

5.2.2 Labels on shipped containers shall not be removed or defaced unless the identical information is reinstalled on the container.

5.2.3 Containers in the workplace (i.e., secondary containers, portable and stationary tanks, etc.) shall be labeled with the criteria listed in Section 5.2.1, or the product identifier and words, pictures, symbols, or combination thereof, which provide at least general information regarding the physical hazards of the chemical.

5.2.4 Damaged labels or labels with incomplete information shall be reported immediately.

5.2.5 Workplace labels or other forms of warning will be legible, in English and prominently displayed on the container or readily available in the work area throughout each work shift. If employees speak languages other than English, the information in the other language(s) may be added to the material presented as long as the information is presented in English as well.

5.3 SDSs:

5.3.1 SDSs must be received with the initial order of the hazardous substance and shall be forwarded to the OSC for office locations, or the appropriate Project Manager for field work.

5.3.2 The OSC shall maintain a current file of SDSs for their respective office locations.

5.3.3 Project Managers shall maintain a current file of SDSs for their respective projects:

- Project Managers shall offer SDSs to affected contractors, clients, and other personnel who could be exposed to chemicals used by TRC on project sites.

5.3.4 Outside contractors shall be informed by the OSC of the materials to which they may be exposed at TRC office locations. Copies of the SDSs for substances in use while the contractor is on the premises shall be supplied by the contractor upon request.

5.3.5 All SDSs will be accessible to all TRC personnel electronically via TRCNET, or paper copy maintained by the OSC or Project Manager. TRC employees will be provided SDSs promptly upon request.

5.4 Multi-Employer Job Sites and/or Multi Work Site:

Chemical information is provided to employees on multiple worksites or multiple employer worksites. The following specific methods for providing other employer information concerning hazardous chemicals at job sites, methods of providing SDS sheets, methods of precautionary measures to be taken and methods of providing information on labeling systems:

- Multi-Work Sites:

  Where employees must travel between work places during a work shift (multi job sites), the written program may be kept at a primary job site. If there is no primary, then the program should be sent with employees.

- Multi-Employer Job Sites:

  A pre-job briefing shall be conducted with the contractor prior to the initiation of work on the site.

  - During this pre-job briefing, contractors shall notify TRC and present current copies of Safety Data Sheets and label information for every hazardous chemical brought on-site.
  - All contractors shall notify and provide required SDS and label information for all hazardous chemicals the contractor may encounter on the job.
  - The facilities labeling system and any precautionary measures to be taken by contractor during normal conditions and emergencies shall be addressed.
  - By providing such information to other employers, TRC does not assume any obligations that other employers have for the safety of their employees.

5.5 Training:

5.5.1 All TRC employees shall receive Hazard Communication training upon being hired. At a minimum, the training shall include:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area.
- General physical and health hazards associated with chemicals and the precautions necessary to prevent injury/illness.
- Requirements of the OSHA Hazard Communication Standard.
- TRC's written Hazard Communication Program.
- How to access SDSs during their Health and Safety orientation. Container labeling requirements including new Globally Harmonized System (GHS) labeling elements and SDS format. (See Figures 1 and 2).
- Instructions on how to read and understand information contained in an SDS and where the SDS can be found.
- Operations where hazardous chemicals may be present, and potential health hazards to which the employee(s) may be exposed.
- Methods for detecting the presence of a hazardous chemical release.

5.5.2 Employees who may be exposed to hazardous substances while performing their job shall receive specific training on the chemical hazards and precautions necessary to prevent injury/illness.

5.5.3 If a new hazard is introduced into the workplace, affected employees shall receive training addressing the new hazard.

5.5.4 Employees that perform non-routine tasks will be trained on the hazards of the non-routine task prior to the work beginning.

5.6 Annual Review:

5.6.1 The Hazard Communication Program shall be reviewed by the TRC National Safety Director or designee on an annual basis (see Figure 3) to ensure it remains effective.

5.7 Records:

5.7.1 SDSs associated with employee exposures shall be retained for 30 years after the date of the last exposure.

6. REFERENCES/RELATED DOCUMENTATION

CP003 Personal Protective Equipment

29 CFR 1910.1200 Hazard Communication

Hazard Communication Training (TRC Safety Academy)

GHS Compliance Training (TRC Safety Academy) Form

CP001.1 Hazardous Substance Inventory

Form CP001.1
Hazardous Substance Inventory

OFFICE LOCATION	HAZARDOUS Substance	CHEMICAL LOCATION / AREA USED (OPTIONAL)	SDSs ON FILE (X)

Figure 1
Example GHS Label

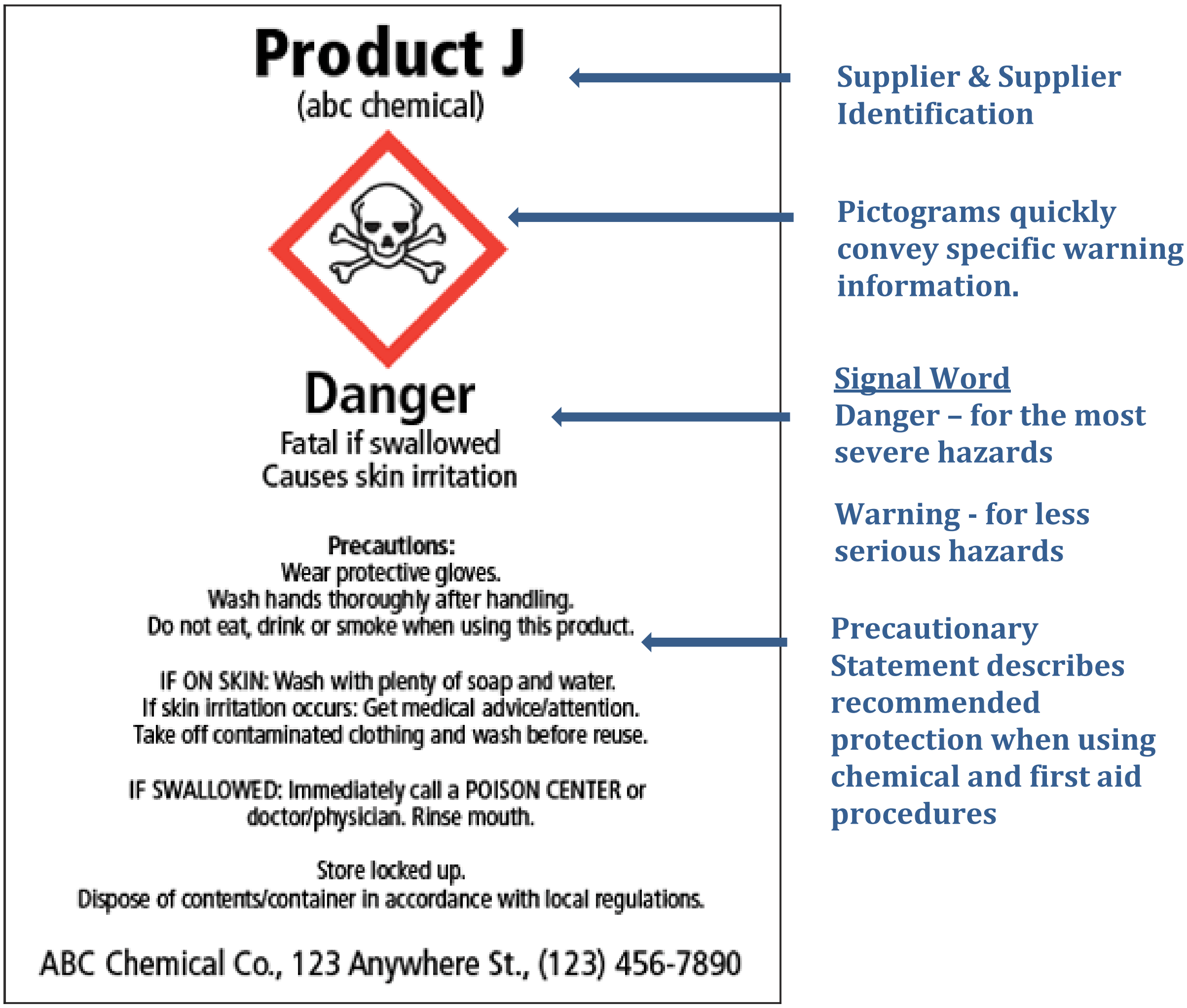


Figure 2
GHS Pictogram

HC

Health Hazard  ▪ **Carcinogen** ▪ **Mutagenicity** ▪ **Reproductive Toxicity** ▪ **Respiratory Sensitizer** ▪ **Target Organ Toxicity** ▪ **Aspiration Toxicity**	**Flame**  ▪ **Flammables** ▪ **Pyrophorics** ▪ **Self-Heating** ▪ **Emits Flammable Gas** ▪ **Self-Reactives** ▪ **Organic Peroxides**	**Exclamation Mark**  ▪ **Irritant (skin and eye)** ▪ **Skin Sensitizer** ▪ **Acute Toxicity** ▪ **Narcotic Effects** ▪ **Respiratory Tract Irritant** ▪ **Hazardous to Ozone Layer (Non-Mandatory)**
Gas Cylinder  ▪ **Gases Under Pressure**	**Corrosion**  ▪ **Skin Corrosion/Burns** ▪ **Eye Damage** ▪ **Corrosive to Metals**	**Exploding Bomb**  ▪ **Explosives** ▪ **Self-Reactives** ▪ **Organic Peroxides**
Flame Over Circle  ▪ **Oxidizers**	**Environment** **(Non-Mandatory)**  ▪ **Aquatic Toxicity**	**Skull and Crossbones**  ▪ **Acute Toxicity (fatal or toxic)**

Figure 3
Annual Review Checklist

		ACTIONS REQUIRED	DATE FOR ACTION TO BE COMPLETED
1.	Review of written compliance program	____________________	__________
2.	Hazardous materials inventory	____________________	__________
3.	SDS file update	____________________	__________
4.	Review of training program	____________________	__________
5.	Office review (attach list)	____________________	__________
	______________________________	____________________	__________
	______________________________	____________________	__________
	______________________________	____________________	__________
	______________________________	____________________	__________
	______________________________	____________________	__________
	______________________________	____________________	__________

Reviewer's Signature: ____________________________________ Date Completed: __________

1. PURPOSE

TRC's Electrical Safety Program has been developed based on the Occupational Safety and Health Administration (OSHA) standards for the construction industry (29 CFR 1926, Subpart K – Electrical) and general industry (29 CFR 1910, Subpart S – Electrical) to protect employees from hazards in the electrical industry.

2. SCOPE

This Compliance Program covers the construction and maintenance of electric power equipment. As used in this Compliance Program, the term "construction" includes the installation of new electric equipment, and the alteration, conversion, and improvement of existing electric equipment. This Compliance Program does not apply to electrical safety-related work practices for unqualified employees. These guidelines apply to all Operating Unit facilities and project sites.

3. DEFINITIONS

<u>Acceptable</u>: An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart K:

- If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a qualified testing laboratory capable of determining the suitability of materials and equipment for installation and use in accordance with this standard;
- With respect to an installation or equipment of a kind which no qualified testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with those provisions; or
- With respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which TRC keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

<u>Accepted</u>: An installation is "accepted" if it has been inspected and found to be safe by a qualified testing laboratory.

<u>Accessible</u>: (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "concealed" and "exposed.")

<u>Accessible</u>: (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See "Readily accessible.")

Ampacity: The current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Appliances: Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions.

Approved: Acceptable to the authority enforcing this Subpart. The authority enforcing this Subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this Subpart.

Askarel**:** A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap or Cap): A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic: Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

Bare conductor**:** See "Conductor."

Bonding: The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper: A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Building**:** A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet**:** An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

Certified: Equipment is "certified" if it:

- Has been tested and found by a qualified testing laboratory to meet applicable test standards or to be safe for use in a specified manner; and
- Is of a kind whose production is periodically inspected by a qualified testing laboratory. Certified equipment must bear a label, tag, or other record of certification.

Circuit breaker:

- (600 volts nominal, or less.) A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.
- (Over 600 volts, nominal.) A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Class I locations**:** Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following:

- A Class I, Division 1 location is a location:
  - In which ignitable concentrations of flammable gases or vapors may exist under normal operating conditions; or
  - In which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or
  - In which breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

  NOTE: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

- A Class I, Division 2 location is a location:
  - In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment;
  - In which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or
  - That is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

  NOTE: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

  Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

  Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

<u>Class II locations</u>: Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

- Class II, Division 1: A Class II, Division 1 location is a location:
  - In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures;
  - Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or

  - In which combustible dusts of an electrically conductive nature may be present.

  NOTE: Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

- Class II, Division 2: A Class II, Division 2 location is a location in which:
  - Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or
  - Dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitable by abnormal operation or failure of electrical equipment or other apparatus.

  NOTE: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

<u>Class III locations</u>: Class III locations are those that are hazardous because of the presence of easily ignitable fibers or filings, but in which such fibers or filings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following:

- Class III, Division 1: A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible filings are handled, manufactured, or used.

NOTE: Easily ignitable fibers and filings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, sawdust, woodchips, and other material of similar nature.

- Class III, Division 2: A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled, except in process of manufacture.

<u>Collector Ring</u>: A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

Concealed: Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. (See "Accessible. [As applied to wiring methods.]")

Conductor:

- Bare: A conductor having no covering or electrical insulation whatsoever.
- Covered: A conductor encased within material of composition or thickness that is not recognized as electrical insulation.
- Insulated: A conductor encased within material of composition and thickness that is recognized as electrical insulation.

Controller: A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Covered conductor**:** See "Conductor."

Cutout**:** (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box**:** An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "Cabinet.")

Damp location: See "Location."

Dead front**:** Without live parts exposed to a person on the operating side of the equipment.

Device**:** A unit of an electrical system which is intended to carry but not utilize electric energy.

Disconnecting means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch (Over 600 volts, nominal): A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dry location**:** See "Location."

Enclosed**:** Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure**:** The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Equipment**:** A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

Equipment grounding conductor**:** See "Grounding conductor, equipment."

Explosion-proof apparatus: Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed**:**

- As applied to live parts: Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "Accessible" and "Concealed.")
- As applied to wiring methods: On or attached to the surface or behind panels designed to allow access. (See "Accessible. [As applied to wiring methods.]")
- For the purposes of § 1926.408(d), Communications systems: Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable**:** Capable of being operated without exposing the operator to contact with live parts.

Feeder**:** All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Festoon lighting**:** A string of outdoor lights suspended between two points more than 15 feet (4.57 m) apart.

Fitting: An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Fuse (Over 600 volts, nominal): An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground**:** A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded**:** Connected to earth or to some conducting body that serves in place of the earth.

Grounded, effectively (Over 600 volts, nominal): Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Grounded conductor: A system or circuit conductor that is intentionally grounded.

Grounding conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment**:** The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Grounding electrode conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

Ground-fault circuit interrupter: A device for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded**:** Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Hoistway**:** Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified (conductors or terminals): Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be recognized as grounded.

Identified (for the use): Recognized as suitable for the specific purpose, function, use, environment, application, etc. where described as a requirement in this standard. Suitability of equipment for a specific purpose, environment, or application is determined by a qualified testing laboratory where such identification includes labeling or listing.

Insulated conductor: See "Conductor."

Interrupter switch (Over 600 volts, nominal): A switch capable of making, carrying, and interrupting specified currents.

Intrinsically safe equipment and associated wiring**:** Equipment and associated wiring in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under certain prescribed test conditions, of causing ignition of a mixture of flammable or combustible material in air in its most easily ignitable concentration.

Isolated: Not readily accessible to persons unless special means for access are used.

Isolated power system: A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled**:** Equipment or materials to which has been attached a label, symbol or other identifying mark of a qualified testing laboratory which indicates compliance with appropriate standards or performance in a specified manner.

Lighting outlet**:** An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Listed**:** Equipment or materials included in a list published by a qualified testing laboratory whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Location**:**

- Damp location: Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements.
- Dry location: A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.
- Wet location: Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected.

Mobile X-ray**:** X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Motor control center**:** An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Outlet**:** A point on the wiring system at which current is taken to supply utilization equipment.

Overcurrent**:** Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

Overload: Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See "Overcurrent.")

Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "Switchboard.")

Portable X-ray**:** X-ray equipment designed to be hand-carried.

Power fuse (Over 600 volts, nominal): See "Fuse."

Power outlet**:** An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises wiring system**:** That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person**:** One familiar with the construction and operation of the equipment and the hazards involved.

Qualified testing laboratory**:** A properly equipped and staffed testing laboratory which has capabilities for and which provides the following services:

- Experimental testing for safety of specified items of equipment and materials referred to in this standard to determine compliance with appropriate test standards or performance in a specified manner;
- Inspecting the run of such items of equipment and materials at factories for product evaluation to assure compliance with the test standards;
- Service-value determinations through field inspections to monitor the proper use of labels on products and with authority for recall of the label in the event a hazardous product is installed;

- Employing a controlled procedure for identifying the listed and/or labeled equipment or materials tested; and
- Rendering creditable reports or findings that are objective and without bias of the tests and test methods employed.

Raceway**:** A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Readily accessible**:** Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "Accessible.")

Receptacle**:** A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

Receptacle outlet: An outlet where one or more receptacles are installed.

Remote-control circuit: Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment**:** Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system**:** A premises wiring system whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service: The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service conductors**:** The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Service drop**:** The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance conductors, overhead system**:** The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service-entrance conductors, underground system**:** The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service equipment: The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service raceway: The raceway that encloses the service-entrance conductors.

Signaling circuit**:** Any electric circuit that energizes signaling equipment.

Switchboard**:** A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets (See "Panelboard").

Switches:

- General-use switch: A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.
- General-use snap switch: A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.
- Isolating switch: A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.
- Motor-circuit switch: A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices (Over 600 volts, nominal): Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, and interrupter switches.

Transportable X-ray: X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment: Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

Utilization system: A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

Ventilated**:** Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid: A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 40 psi (276 kPa) at 38 deg. C (100 deg. F) whose temperature is above its flash point.

Voltage (Of a circuit): The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal: A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground**:** For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight: So constructed that moisture will not enter the enclosure.

Weatherproof: So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, rain tight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wet location: See "Location."

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for establishing the Electrical Safety Program requirements and providing/communicating them to employees. The National Safety Director will coordinate with the Project Manager and the TRC Contracts Department to review contract documents to identify project- and client-specific requirements, as necessary.

4.2 The Health and Safety Network is responsible for Electrical Safety Program implementation including, but not limited to provide PPE for electrical work which meets the established American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) standards.

- Train new and existing TRC site employees (CP009 Health and Safety Training compliance program).
- Communicate and coordinate TRC's Electrical Safety Program requirements with all TRC subcontractors.
- Ensure that all TRC and contracted employees are aware of electrical hazards on site and that contracted workers are properly qualified to work on or around electrical equipment.
- Review and approve of all TRC and subcontractor daily Job Safety Analysis (JSA) forms and equipment inspections.
- Perform program audits and inspections in conjunction with on-site TRC subcontractor, and site Health and Safety representatives or their designees.
- Maintaining electrical safety records for Health and Safety activities on-site including equipment inspections and procedural audits of site employee work practice implementation (see Sections 13 and 14, Audits and Inspections, and Documentation).

The Health and Safety Network will be determined prior to the mobilization of any TRC employees or contractors.

4.3 The HASP includes Safety and Incident Response guidelines and procedures, nearby medical facility information, safety personnel contact information, and specific JSA for each major task. The JSAs should identify basic job steps, potential hazards, and recommended safety procedures. JSAs are included for the tasks identified in the project plan as well as site mobility, driving, and other areas of hazard and risk.

4.4 A detailed Job Safety Analysis (JSA) for the intended work tasks should be developed in conjunction with the identified hazards. The JSA shall break down the work process into individual tasks and identify the hazards associated with those tasks. All identified hazards shall have corresponding corrective steps identified for mitigation. See TRC's JSA Program.

4.5 The Construction Manager is responsible to review, manage and coordinate all on-site activities, and include Safety programs of Subcontractors, Vendors or Suppliers. Prior to any work being performed by the Subcontractor personnel, Project Safety documentation and plans need to be submitted and approved by the Construction Manager. During the course of the work, the Construction Manager is responsible to assure that the Subcontractor's program is being enforced and adhered to. Each and every Subcontractor is responsible for maintaining their programs in a satisfactory and effective manner including assigning Competent Persons as required by OSHA and APPA. The Construction Manager shall audit the Subcontractor's program documentation at any time to assure the program is effective, and in compliance. The Construction Manager holds the ultimate power to issue stop work orders to Subcontractors if there is concern about the effectiveness or accuracy/completeness of the program and/or program documentation.

4.6 A Competent Person shall be assigned to develop plans, and monitor the overall effectiveness of those plans and provide corrective actions if required, as defined by OSHA 1926 and the APPA manual for work being performed by TRC employees. The Competent Person can be any employee assigned to the work and defined as competent. In some projects, the Lead Commissioning Engineer (LCE) is designated as the Construction Manager and Competent Person.

4.7 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the Electrical Safety Program. Project Managers must hold all site employees and subcontractors accountable for safe work and maintaining a safe work environment.

4.8 Lead Commissioning Engineer:

4.8.1 The Lead Commissioning Engineer is responsible for the following:

- Take a leadership role in the planning and execution of the entire commissioning process in accordance with the guidelines and procedures established by TRC.
- Ensure the safety of his/her staff and the Craft workers who may be assisting or could accidentally come in contact with equipment that is energized and under test. The Commissioning Engineering Team shall conduct Tailboard Meetings and use temporary signage, barrier tape and flagging as necessary to ensure that all site personnel respect established test boundaries, and are prevented from entering energized test work areas.
- Ensure safety and integrity of all equipment under test and verifying that all components and systems are tested consistent with the manufacturer's stated recommendations.
- Another important aspect of safety concerns the protection and integrity of existing in-service equipment and systems located adjacent to or sometimes even within the same control cabinet where construction activities are planned. It is vitally important that every member of the Commissioning Engineering Team is familiar with and has assessed and discussed all site risks as well as the daily commissioning work plan.

These processes detail the precautions that must be taken to minimize the potential for unintended operation and/or injury to personnel.

4.8.2 The Lead Commissioning Engineer's Specific Safety Responsibilities:

In many cases, the Lead Commissioning Engineer is the TRC person on-site responsible for all work activities during the commissioning phase of the project. It is imperative that the Lead Commissioning Engineer be very familiar with all aspects of safe work practices. The Lead Commissioning Engineer must be familiar with both the TRC Safety Manual and the customer's safety policies.

Usually the commissioning activities begin before the construction phase of the project is complete. It is important that the Lead Commissioning Engineer be aware of ongoing constructions activities to safely perform commissioning tests.

The Lead Commissioning Engineer needs to provide guidance to the electricians and/or technicians working on or around live equipment and systems. The Lead Commissioning Engineer shall use temporary labels or tags to highlight equipment and/or circuits that require extra caution while working on or around them, and make certain only qualified personnel work on or around live equipment and circuits. The Lead Commissioning Engineer shall make certain they are completely aware of what they are doing and emphasize that everyone should stop and discuss the situation if they have any questions. Safety first is always the top priority.

The Lead Commissioning Engineer needs to be aware of the safety aspects in regards to the equipment as well as the personnel. The Lead Commissioning Engineer shall not perform any test that presents undue risk of damage or destruction to new or existing equipment, or creates an undue risk of causing an inadvertent outage, or one that creates an unacceptable safety hazard to the employees conducting the test, or those in the proximity of the equipment under test. Any unusual tests being considered require careful planning and a thorough review to insure both personnel and equipment will be safe.

4.8.3 Lead Commissioning Engineer's Responsibility to Perform Tailboard Meetings and Safety Briefings:

At the beginning of commissioning activities, the Lead Commissioning Engineer shall hold a general Tailboard Meeting with all personnel who will be working on that phase of the project, as well as those who may be working in the area. The Tailboard Meeting shall cover topics of Safety while working on or around energized equipment or circuits, appropriate tools and test equipment to be used, working with the drawings, switching and tagging procedures, work being performed by others that they need to be aware of, and any special circumstances specific to that project.

At the start of each work day and anytime the work scope or environment changes, the Lead Commissioning Engineer shall conduct a brief Tailboard Meeting to discuss the work taking place that day, and any specific considerations (energizing new equipment or systems, switching, testing, etc.).

When any new personnel arrive to perform commissioning work, the Lead Commissioning Engineer needs to make certain they are thoroughly briefed on all aspects of the work practices for that location, similar to the initial Tailboard Meeting described above.

TRC Tailboard Sheets are provided in Appendix B of the TRC Power Delivery Engineering Commissioning Procedures.

4.8.4 The Lead Commissioning Engineer's Responsibility to Perform a Risk Assessment and Safety Review:

Following mobilization and prior to beginning any work, a Site Risk Assessment is performed. A thorough risk assessment creates awareness of the site, system, and safety risks. The Lead Commissioning Engineer discusses identified risks with the project team and takes the necessary measures to mitigate the risks. Several items are considered when performing a risk assessment:

- Personnel Safety – This is reviewed in conjunction with the HASP and associated JSAs. Review any additional safety risks not initially identified in the HASP or JSAs. Review zones of clearance, minimum approach distances, PPE requirements, lock-out-tag-out procedures and tag holders.
- Site Team - Review the experience of and qualifications of each member to perform their duties as assigned. Review the confidence levels of the personnel; overconfidence can be more dangerous than lack of confidence.
- Site Status.

- Construction Drawing Packages.
- Existing Station Drawings.
- Instruction Manuals.
- Project Documents and Plans.
- Test Equipment and Proper Tools.
- System Risks.
- Schedule.

4.9 All Site Employees involved with electrical work shall be held accountable for performing work in a safe manner according to the requirements of this program. All employees will be required to participate in JSA training, and to participate in the daily development and review of work-specific JSAs.

All site employees, when they observe a hazard condition of any type, shall report it to the proper individual.

5. PROCEDURE

5.1 Wiring Design and Protection

5.1.1 Use and identification of grounded and grounding conductors:

- Identification of conductors: A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.
- Polarity of connections: No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.
- Use of grounding terminals and devices: A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug shall not be used for purposes other than grounding.

5.1.2 Branch circuits:

- General: TRC shall use either ground fault circuit interrupters or an assured equipment grounding conductor program to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.

- Ground-fault circuit interrupters: All 120-volt, single-phase 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.
- Assured equipment grounding conductor program: TRC shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:
  - A written description of the program, including the specific procedures adopted by TRC, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.
  - TRC shall designate one or more competent persons to implement the program.
  - Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.
  - The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded:
    - All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.
    - Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.
  - All required tests shall be performed:
    - Before first use;
    - Before equipment is returned to service following any repairs;

        - Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and
        - At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.
    - TRC shall not make available or permit the use by employees of any equipment which has not met the requirements of this section.
    - Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.
- Outlet devices. Outlet devices shall have an ampere rating not less than the load to be served and shall comply with the following:
    - Single receptacles. A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.
    - Two or more receptacles. Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table K-4.
    - Receptacles used for the connection of motors. The rating of an attachment plug or receptacle used for cord- and plug-connection of a motor to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts if individual overload protection is omitted.

TABLE K-4 - Receptacle Ratings for Various Size Circuits

Circuit rating amperes	Receptacle rating amperes
15	Not over 15.
20	15 or 20.
30	30.
40	40 or 50.
50	50.

5.1.3 Outside conductors and lamps (600 volts, nominal, or less):
This section applies to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors.

- Conductors on poles. Conductors supported on poles shall provide a horizontal climbing space not less than the following:
  - Power conductors below communication conductors-30 inches (762 mm).
  - Power conductors alone or above communication conductors: 300 volts or less-24 inches (610 mm); more than 300 volts-30 inches (762 mm).
  - Communication conductors below power conductors: with power conductors 300 volts or less-24 inches (610 mm); more than 300 volts-30 inches (762 mm).
- Clearance from ground: Open conductors shall conform to the following minimum clearances:
  - 10 feet (3.05 m)-above finished grade, sidewalks, or from any platform or projection from which they might be reached.
  - 12 feet (3.66 m)-over areas subject to vehicular traffic other than truck traffic.
  - 15 feet (4.57 m)-over areas other than those specified in this section that are subject to truck traffic.
  - 18 feet (5.49 m)-over public streets, alleys, roads, and driveways.
- Clearance from building openings: Conductors shall have a clearance of at least 3 feet (914 mm) from windows, doors, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet (914 mm) away.

- Clearance over roofs: Conductors above roof space accessible to employees on foot shall have a clearance from the highest point of the roof surface of not less than 8 feet (2.44 m) vertical clearance for insulated conductors, not less than 10 feet (3.05 m) vertical or diagonal clearance for covered conductors, and not less than 15 feet (4.57 m) for bare conductors, except that:
    - Where the roof space is also accessible to vehicular traffic, the vertical clearance shall not be less than 18 feet (5.49 m);
    - Where the roof space is not normally accessible to employees on foot, fully insulated conductors shall have a vertical or diagonal clearance of not less than 3 feet (914 mm);
    - Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches (102 mm) in 12 inches (305 mm), the clearance from roofs shall be at least 3 feet (914 mm); or
    - Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet (1.22 m) of the overhang portion of the roof and they are terminated at a through-the-roof raceway or support, the clearance from roofs shall be at least 18 inches (457 mm).
- Location of outdoor lamps: Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

5.1.4 Services (Disconnecting):

- General: Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.
- Simultaneous opening of poles: Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.
- Services over 600 volts, nominal: The following additional requirements apply to services over 600 volts, nominal.
- Guarding: Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

- Warning signs: Signs warning of high voltage shall be posted where unauthorized employees might come in contact with live parts.

5.1.5 Overcurrent protection (600 volts, nominal, or less):
The following requirements apply to overcurrent protection of circuits rated 600 volts nominal or less.

- Protection of conductors and equipment: Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current. Conductors shall have sufficient ampacity to carry the load.
- Grounded conductors: Except for motor-running overload protection, overcurrent devices shall not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.
- Disconnection of fuses and thermal cutouts: Except for devices provided for current-limiting on the supply side of the service disconnecting means, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.
- Location in or on premises: Overcurrent devices shall be readily accessible. Overcurrent devices shall not be located where they could create an employee safety hazard by being exposed to physical damage or located in the vicinity of easily ignitable material.
- Arcing or suddenly moving parts: Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.
- Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.
- Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position.
- If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be marked "SWD."
- Over 600 volts nominal: Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

5.1.6 Grounding:

- Systems to be grounded: The following systems which supply premises wiring shall be grounded:
  - Three-wire DC systems. All 3-wire DC systems shall have their neutral conductor grounded.
  - Two-wire DC systems. Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless they are rectifier-derived from an AC system.
  - AC circuits, less than 50 volts. AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.
  - AC systems, 50 volts to 1000 volts. AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions:
    - If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;
    - If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;
    - If the system is nominally rated 240/120 volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or
    - If a service conductor is uninsulated.
  - Unless exempted by the following:
    - Exceptions. AC systems of 50 volts to 1000 volts are not required to be grounded if the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:
      - The system is used exclusively for control circuits,
      - The conditions of maintenance and supervision assure that only qualified persons will service the installation,
      - Continuity of control power is required, and
      - Ground detectors are installed on the control system.
- Portable generators: Under the following conditions, the frame of a portable generator need not be grounded and may serve as the grounding electrode for a system supplied by the generator:

  - The generator supplies only equipment mounted on the generator and/or cord- and plug-connected equipment through receptacles mounted on the generator, and
  - The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.
- Vehicle-mounted generators: Under the following conditions the frame of a vehicle may serve as the grounding electrode for a system supplied by a generator located on the vehicle:
  - The frame of the generator is bonded to the vehicle frame;
  - The generator supplies only equipment located on the vehicle and/or cord- and plug-connected equipment through receptacles mounted on the vehicle or on the generator;
  - The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame; and
  - The system complies with all other provisions of this section.
- Neutral conductor bonding: A neutral conductor shall be bonded to the generator frame if the generator is a component of a separately derived system. No other conductor need be bonded to the generator frame.
- Conductors to be grounded: For AC premises wiring systems the identified conductor shall be grounded.
- Grounded system: For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.
- Ungrounded systems: For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.
- Grounding path: The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

- Supports and enclosures for conductors: Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:
  - Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded.
  - Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met:
    - Runs are less than 25 feet (7.62 m);
    - Enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and
    - Enclosures are guarded against employee contact.
- Service equipment enclosures: Metal enclosures for service equipment shall be grounded.
- Fixed equipment: Exposed noncurrent-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:
  - If within 8 feet (2.44 m) vertically or 5 feet (1.52 m) horizontally of ground or grounded metal objects and subject to employee contact.
  - If located in a wet or damp location and subject to employee contact.
  - If in electrical contact with metal.
  - If in a hazardous (classified) location.
  - If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.
  - If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:
    - Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;
    - Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and
    - The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet (2.44 m) above ground or grade level.

- Equipment connected by cord and plug: Under any of the conditions described in this section, exposed noncurrent-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded:
    - If in a hazardous (classified) location.
    - If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.
    - If the equipment is one of the types listed:
        - Hand held motor-operated tools;
        - Cord- and plug-connected equipment used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;
        - Portable and mobile X-ray and associated equipment;
        - Tools likely to be used in wet and/or conductive locations;
        - Portable hand lamps.
    - However, even though the equipment may be one of these types, it need not be grounded if it is exempted by the following:
        - Tools likely to be used in wet and/or conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by a system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes a system of double insulation.
- Nonelectrical equipment: The metal parts of the following nonelectrical equipment shall be grounded: Frames and tracks of electrically operated cranes; frames of nonelectrically driven elevator cars to which electric conductors are attached; hand-operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over 1 kV between conductors.
- With circuit conductors: Noncurrent-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

- Grounding conductor: A conductor used for grounding fixed or movable equipment shall have capacity to conduct safely any fault current which may be imposed on it.
- Equipment considered effectively grounded: Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the noncurrent-carrying metal parts of fixed equipment in paragraph (f)(8)(i) of this section. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.
- Bonding: If bonding conductors are used to assure electrical continuity, they shall have the capacity to conduct any fault current which may be imposed.
- Made electrodes: If made electrodes are used, they shall be free from nonconductive coatings, such as paint or enamel; and, if practicable, they shall be embedded below permanent moisture level. A single electrode consisting of a rod, pipe or plate which has a resistance to ground greater than 25 ohms shall be augmented by one additional electrode installed no closer than 6 feet (1.83 m) to the first electrode.
- Grounding of systems and circuits of 1000 volts and over (high voltage).
  - Grounding of systems supplying portable or mobile equipment: Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:
    - Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.
    - Exposed noncurrent-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.
    - Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

    - The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet (6.1 m) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence or like objects.

- Grounding of equipment: All noncurrent-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet (2.44 m) above ground or grade level need not be grounded.

5.2 Wiring methods, components, and equipment for general use:

Wiring methods: The provisions of this paragraph do not apply to conductors which form an integral part of equipment such as motors, controllers, and motor control centers and like equipment.

5.2.1 General requirements:

- Electrical continuity of metal raceways and enclosures: Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

- Wiring in ducts: No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type shall be installed in any duct used for vapor removal or in any shaft containing only such ducts.

- Feeders shall originate in a distribution center. The conductors shall be run as multi-conductor cord or cable assemblies or within raceways; or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet (3.05 m) apart.

- Branch circuits shall originate in a power outlet or panelboard. Conductors shall be run as multi-conductor cord or cable assemblies or open conductors, or shall be run in raceways. All conductors shall be protected by overcurrent devices at their ampacity. Runs of open conductors shall be located where the conductors will not be subject to physical damage, and the conductors shall be fastened at intervals not exceeding 10 feet (3.05 m). No branch-circuit conductors shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if the branch circuit is run as open conductors.

- Receptacles shall be of the grounding type unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor. Receptacles for uses other than temporary lighting shall not be installed on branch circuits which supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multi-wire circuits which supply temporary lighting.
- Disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.
- All lamps for general illumination shall be protected from accidental contact or breakage. Metal-case sockets shall be grounded.
- Temporary lights shall not be suspended by their electric cords unless cords and lights are designed for this means of suspension.
- Portable electric lighting used in wet and/or other conductive locations, as for example, drums, tanks, and vessels, shall be operated at 12 volts or less. However, 120-volt lights may be used if protected by a ground-fault circuit interrupter.
- A box shall be used wherever a change is made to a raceway system or a cable system which is metal clad or metal sheathed.
- Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided. Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage.
- Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra-hard usage. Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage.
- Guarding: For temporary wiring over 600 volts, nominal, fencing, barriers, or other effective means shall be provided to prevent access of other than authorized and qualified personnel

5.2.2 Cabinets, boxes, and fittings:

- Conductors entering boxes, cabinets, or fittings: Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall also be effectively closed.

- Covers and canopies: All pull boxes, junction boxes, and fittings shall be provided with covers. If metal covers are used, they shall be grounded. In energized installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.
- Pull and junction boxes for systems over 600 volts, nominal. In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:
    - Complete enclosure: Boxes shall provide a complete enclosure for the contained conductors or cables.
    - Covers: Boxes shall be closed by covers securely fastened in place. Underground box covers that weigh over 100 pounds (43.6 kg) meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

5.2.3 Knife switches:

Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

5.2.4 Switchboards and panelboards:

Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

5.2.5 Enclosures for damp or wet locations:

- Cabinets, fittings, and boxes: Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

- Switches and circuit breakers: Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

5.2.6 Conductors for general wiring:

All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is suitable for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

5.2.7 Use of flexible cords and cables:

- Permitted uses:
  - Flexible cords and cables shall be suitable for conditions of use and location. Flexible cords and cables shall be used only for:
    - Pendants;
    - Wiring of fixtures;
    - Connection of portable lamps or appliances;
    - Elevator cables;
    - Wiring of cranes and hoists;
    - Connection of stationary equipment to facilitate their frequent interchange;
    - Prevention of the transmission of noise or vibration; or
    - Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair.
- Attachment plugs for cords: If use, the flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet.
- Prohibited uses:
  - Flexible cords and cables shall not be used:
    - As a substitute for the fixed wiring of a structure;
    - Where run through holes in walls, ceilings, or floors;
    - Where run through doorways, windows, or similar openings;

- Where attached to building surfaces; or
- Where concealed behind building walls, ceilings, or floors.

- Identification: A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors.
- Marking: Type SJ, SJO, SJT, SJTO, S, SO, ST, and STO cords shall not be used unless durably marked on the surface with the type designation, size, and number of conductors.
- Splices: Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.
- Strain relief: Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.
- Cords passing through holes: Flexible cords and cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

5.2.8 Portable cables over 600 volts nominal:

Multi-conductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables shall not be operated with splices unless the splices are of the permanent molded, vulcanized, or other equivalent type. Termination enclosures shall be marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

5.2.9 Fixture wires:

- General: Fixture wires shall be suitable for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.
- Uses permitted:
  - Fixture wires may be used:

- For installation in lighting, fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or
- For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

- Uses not permitted: Fixture wires shall not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

5.2.10 Equipment for general use:

Lighting fixtures, lampholders, lamps, and receptacles:

- Live parts: Fixtures, lampholders, lamps, rosettes, and receptacles shall have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet (2.44 m) above the floor may have exposed parts.
- Support: Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture that weighs more than 6 pounds (2.72 kg) or exceeds 16 inches (406 mm) in any dimension shall not be supported by the screw shell of a lampholder.
- Portable lamps: Portable lamps shall be wired with flexible cord and an attachment plug of the polarized or grounding type. If the portable lamp uses an Edison-based lampholder, the grounded conductor shall be identified and attached to the screw shell and the identified blade of the attachment plug. In addition, portable handlamps shall comply with the following:
  - Metal shell, paperlined lampholders shall not be used;
  - Handlamps shall be equipped with a handle of molded composition or other insulating material;
  - Handlamps shall be equipped with a substantial guard attached to the lampholder or handle; and
  - Metallic guards shall be grounded by the means of an equipment grounding conductor run within the power supply cord.
- Lampholders: Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.
- Fixtures: Fixtures installed in wet or damp locations shall be identified for the purpose and shall be installed so that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

5.2.11 Receptacles, cord connectors, and attachment plugs (caps):

- Configuration. Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a different voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.
- Damp and wet locations. A receptacle installed in a wet or damp location shall be designed for the location.

5.2.12 Appliances:

- Live parts: Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, shall have no live parts normally exposed to employee contact.
- Disconnecting means: A means shall be provided to disconnect each appliance.
- Rating: Each appliance shall be marked with its rating in volts and amperes or volts and watts.

5.2.13 Motors:

Motors, motor circuits, and controllers:

- In sight from: If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet (15.2 m.) from the other.
- A disconnecting means shall be located in sight from the controller location. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.
- The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.
- If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

- The controller disconnecting means shall be capable of being locked in the open position.
- A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

- The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.
- The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.
- An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions:
  - If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;
  - If a group of motors is under the protection of one set of branch-circuit protective devices; or
  - If a group of motors is in a single room in sight from the location of the disconnecting means.
- Motor overload, short-circuit, and ground-fault protection: Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions do not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.
- Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:
  - By installation in a room or enclosure that is accessible only to qualified persons;
  - By installation on a balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or
  - By elevation 8 feet (2.44 m) or more above the floor.

- Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

5.2.14 Transformers:

- The following covers the installation of all transformers, except:
  - o Current transformers;
  - o Dry-type transformers installed as a component part of other apparatus;
  - o Transformers which are an integral part of an X-ray, high frequency, or electrostatic-coating apparatus; and
  - o Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signaling circuits.
- Operating voltage: The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.
- Transformers over 35 kV: Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35 kV shall be in a vault.
- Oil-insulated transformers: If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.
- Fire protection: Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.
- Transformer vaults: Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.
- Pipes and ducts: Any pipe or duct system foreign to the vault installation shall not enter or pass through a transformer vault.
- Material storage: Materials shall not be stored in transformer vaults.

5.2.15 Capacitors:

- Drainage of stored charge: All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge and maintaining the discharged state after the capacitor is disconnected from its source of supply.
- Over 600 volts: Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:
    - Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.
    - For series capacitors the proper switching shall be assured by use of at least one of the following:
        - Mechanically sequenced isolating and bypass switches,
        - Interlocks, or
        - Switching procedure prominently displayed at the switching location.

5.3 Specific purpose equipment and installations:

5.3.1 Cranes and hoists:

This section applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

- Runway conductor disconnecting is a readily accessible disconnector which shall be provided between the runway contact conductors and the power supply.
- Disconnecting means for cranes and monorail hoists: A disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply on any crane or monorail hoist.
- If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.
- The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:
    - The unit is floor controlled;
    - The unit is within view of the power supply disconnecting means; and

- No fixed work platform has been provided for servicing the unit.

5.3.2 Control: A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

5.3.3 Clearance: The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches (762 mm). Where controls are enclosed in cabinets, the door(s) shall open at least 90 degrees or be removable, or the installation shall provide equivalent access.

5.3.4 Grounding: All exposed metal parts of cranes, monorail hoists, hoists and accessories including pendant controls shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded. Moving parts, other than removable accessories or attachments, having metal-to-metal bearing surfaces shall be considered to be electrically connected to each other through the bearing surfaces for grounding purposes. The trolley frame and bridge frame shall be considered as electrically grounded through the bridge and trolley wheels and its respective tracks unless conditions such as paint or other insulating materials prevent reliable metal-to-metal contact. In this case a separate bonding conductor shall be provided.

5.3.5 Elevators, escalators, and moving walks:

- Disconnecting: Elevators, escalators, and moving walks shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.
- Control panels: If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

5.3.6 X-Ray equipment (Disconnecting):

- General: A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.
- More than one piece of equipment: If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or

located so as to avoid contact by employees with its live parts.

- Control-Radiographic and fluoroscopic types: Radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that deenergize the equipment automatically to prevent ready access to live current-carrying parts.

5.4 Hazardous (classified) locations:

This section sets forth requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows: Class I, Division 1 Class I, Division 2 Class II, Division 1 Class II, Division 2 Class III, Division 1 Class III, Division 2.

5.4.1 Electrical installations:

Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be approved as intrinsically safe or approved for the hazardous (classified) location or safe for the hazardous (classified) location. Requirements for each of these options are as follows:

- Intrinsically safe. Equipment and associated wiring approved as intrinsically safe is permitted in any hazardous (classified) location included in its listing or labeling.

5.4.2 Approved for the hazardous (classified) location:

- General: Equipment shall be approved not only for the class of location but also for the ignitable or combustible properties of the specific gas, vapor, dust, or fiber that will be present.
- Marking: Equipment shall not be used unless it is marked to show the class, group, and operating temperature or temperature range, based on operation in a 40-degree C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas, vapor, or dust to be encountered. However, the following provisions modify this marking requirement for specific equipment:
    - Equipment of the non-heat-producing type (such as junction boxes, conduit, and fitting) and equipment of the heat-producing type having a maximum temperature of not more than 100 degrees C (212 degrees F) need not have a marked operating temperature or temperature range.

- Fixed lighting fixtures marked for use only in Class I, Division 2 locations need not be marked to indicate the group.
- Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.
- Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

5.4.3 Safe for the hazardous (classified) location. Equipment which is safe for the location shall be of a type and design which TRC demonstrates will provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

- Conduits: All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

5.5 Special systems (Systems over 600 volts, nominal):

5.5.1 Wiring methods for fixed installations:

- Above ground: Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable designed for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations which are accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.
- Installations emerging from the ground: Conductors emerging from the ground shall be enclosed in raceways. Raceways installed on poles shall be of rigid metal conduit, intermediate metal conduit, PVC schedule 80 or equivalent extending from the ground line up to a point 8 feet (2.44 m) above finished grade. Conductors entering a building shall be protected by an enclosure from the ground line to the point of entrance. Metallic enclosures shall be grounded.

5.5.2 Interrupting and isolating devices:

- Circuit breakers: Circuit breakers located indoors shall consist of metal-enclosed or fire-resistant, cell-mounted units. In locations accessible only to qualified personnel, open mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

- Fused cutouts: Fused cutouts installed in buildings or transformer vaults shall be of a type identified for the purpose. They shall be readily accessible for fuse replacement.
- Equipment isolating means: A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load current of the circuit shall be either interlocked with a circuit interrupter or provided with a sign warning against opening them under load.

5.5.3 Mobile and portable equipment:

- Power cable connections to mobile machines. A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to ground effectively the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and shall be marked with a sign warning of the presence of energized parts.
- Guarding live parts: All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

5.5.4 Tunnel installations:

- Application: The provisions of this section apply to installation and use of high-voltage power distribution and utilization equipment which is associated with tunnels and which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.
- Conductors: Conductors in tunnels shall be installed in one or more of the following:
  - Metal conduit or other metal raceway;

- Type MC cable; or
- Other suitable multi-conductor cable.

- Conductors shall also be so located or guarded as to protect them from physical damage. Multi-conductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multi-conductor cable jacket. The equipment grounding conductor may be insulated or bare.
- Guarding live parts. Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.
- Disconnecting means. A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.
- Grounding and bonding. All nonenergized metal parts of electric equipment and metal raceways and cable sheaths shall be grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet (305 m) throughout the tunnel.

5.5.5 Class 1, Class 2, and Class 3 remote control, signaling, and power-limited circuits:

- Classification: Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations.
- Class 1 circuits:
  - A Class 1 power-limited circuit is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.
  - A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.
- Class 2 and Class 3 circuits:
  - Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

  - The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.
  - The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a Class 3 power source limited by overcurrent protection.
- Application: The maximum circuit voltages of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurrence is not likely.
- Marking: A Class 2 or Class 3 power supply unit shall not be used unless it is durably marked where plainly visible to indicate the class of supply and its electrical rating.

5.5.6 Communications systems:

These provisions for communication systems apply to such systems as central-station-connected and non-central-station-connected telephone circuits, radio receiving and transmitting equipment, and outside wiring for fire and burglar alarm, and similar central station systems.

5.5.7 Protective devices:

- Circuits exposed to power conductors: Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with an approved protector.
- Antenna lead-ins: Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other means that will drain static charges from the antenna system.

5.5.8 Conductor location:

- Outside of buildings receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light or power conductors.
- The clearance between lead-in conductors and any lightning protection conductors shall not be less than 6 feet (1.83 m).
- On poles: Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors shall not be attached to a crossarm that carries light or power conductors.

- Inside of buildings: Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches (50.8 mm) from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation is employed.

5.5.9 Equipment location:

Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

5.5.10 Grounding:

- Lead-in conductors: If exposed to contact with electric light or power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded.
- Antenna structures: Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.
- Equipment enclosures: Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

5.6 Protection of employees:

5.6.1 All PPE used must meet requirements found in applicable laws and regulations. These PPE requirements apply to many different kinds of PPE: arc rated apparel, insulating aprons, general eye and face protection, arc rated face protection, fall protection, testing methods and specifications for footwear, glove and sleeve testing and care, hard hats, arc rated rainwear, visual inspections of rubber protective products and sleeves.

5.6.2 TRC does not permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.

5.6.3 In work areas where the exact location of underground electric powerlines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

5.6.4 Before work is begun TRC shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. TRC will post and maintain proper warning signs where such a circuit exists. TRC will advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

5.6.5 Passageways and open spaces:

- Barriers or other means of guarding shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.
- Working spaces, walkways, and similar locations shall be kept clear of cords so as not to create a hazard to employees.

5.6.6 Load ratings: In existing installations, no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring.

5.6.7 Fuses: When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.

5.6.8 Cords and cables:

- Worn or frayed electric cords or cables shall not be used.
- Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

5.7 Lockout and tagging of circuits:

5.7.1 Controls: Controls that are to be deactivated during the course of work on energized or de-energized equipment or circuits shall be tagged.

5.7.2 Equipment and circuits: Equipment or circuits that are de-energized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.

5.7.3 Tags shall be placed to identify plainly the equipment or circuits being worked on.

- Maintenance of equipment: TRC shall ensure that all wiring components and utilization equipment in hazardous locations are maintained in a dust-tight, dust-ignition-proof, or explosion-proof condition, as appropriate. There shall be no loose or missing screws, gaskets, threaded connections, seals, or other impairments to a tight condition.

5.8 Environmental deterioration of equipment

5.8.1 Deteriorating agents:

Unless identified for use in the operating environment, no conductors or equipment shall be located:

- In damp or wet locations;
- Where exposed to gases, fumes, vapors, liquids, or other agents having a deteriorating effect on the conductors or equipment; or
- Where exposed to excessive temperatures.

5.8.2 Control equipment, utilization equipment, and busways approved for use in dry locations only shall be protected against damage from the weather during building construction.

5.8.3 Protection against corrosion: Metal raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware shall be of materials appropriate for the environment in which they are to be installed.

5.8.4 Batteries of the unsealed type shall be located in enclosures with outside vents or in well ventilated rooms and shall be arranged so as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

5.8.5 Ventilation shall be provided to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture.

5.8.6 Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

5.8.7 Floors shall be of acid resistant construction unless protected from acid accumulations.

5.8.8 Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

5.8.9 Facilities for quick drenching of the eyes and body shall be provided within 25 feet (7.62 m) of battery handling areas.

5.8.10 Facilities shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

6. REFERENCES / RELATED DOCUMENTS:

American Public Power Association (APPA) Safety Manual, Safety Manual for an Electric Utility

NFPA 70E – Electrical Safety in the Workplace

29 CFR 1910 Subpart S – Electrical

29 CFR 1926 Subpart K – Electrical

ANSI Z89.1 - Requirements for Protective Headwear for Industrial Workers

ANSI Z41 - Standard for Personnel Protection - Protective Footwear

ANSI/ASSE Z87.1 - Practice for Occupational and Educational Eye and Face Protection

ASTM D120 - Standard Specification for Rubber Insulating Gloves

ASTM D1051 - Standard Specification for Rubber Insulating Sleeves

ASTM F496 - Standard Specification for In-Service Care of Insulating Gloves and Sleeves

ASTM F696 - Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens

ASTM F1117 - Standard Specification for Dielectric Overshoe Footwear

ASTM F1236 - Standard Guide for Visual Inspection of Electrical Protective Rubber Products

ASTM F1506 - Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers When Exposed to Momentary Electric Arc and Related Thermal Hazards

National Electric Code (NEC)

National Electrical Safety Code (NESC)

TRC Programs

CP002 – Risk Analysis/Site-Specific Health and Safety Plan

CP003 – Personal Protective Equipment Program

CP004 – Electrical Safety Program

CP005 – Lockout/Tagout Program

CP009 – Health and Safety Training Program

CP019 – TRC Incident Response and Lessons Learned Program

TRC Forms

JSA Forms

LOTO Permit

Site Audit Evaluation Report

Weekly Site Inspection Form

TRC Pre-Job Safety Briefing Form

TRC Daily Work Plan

TRC Weekly Work Plan

1. PURPOSE

The purpose of the Confined Space Entry Program is to set procedures that will ensure workers safe entry into confined spaces and permit-required confined spaces. Employee participation on the development and implementation of all aspects of the permit required confined space entry program is crucial for the success of this program. This procedure is designed to provide the minimum safety requirements in accordance with the Occupational Safety and Health Administration's (OSHA) Confined Space Standards 29 CFR, 1910.146 and 29 CFR 1926 Subpart AA.

2. SCOPE

This program has been developed to protect TRC employees and contractors entering and working in confined spaces by defining mandatory minimum safety requirements for confined space work. This compliance program does not apply to construction in excavations, underground construction, caissons, or cofferdams.

3. DEFINITIONS

Acceptable Entry Conditions**:** The conditions that must exist in a space to allow entry and to ensure that the employees involved with a confined space entry can safely enter into and work within the space.

Attendant: An individual stationed outside one or more spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the confined space entry program.

Authorized Entrant**:** An employee who is authorized by the employer to enter a confined space.

Barrier: A physical obstruction that blocks or limits access.

Blanking or Blinding: The absolute closure of a pipe, line, or duct by the fastening of a solid plate (such as a spectacle blind or a skillet blind) that completely covers the bore and that is capable of withstanding the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

Competent Person: A person who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has the authorization to take prompt corrective measures to eliminate them. Note: This person can act as the Entry Supervisor.

Confined Space: Is defined as a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- Is not designed for continuous employee occupancy.

Controlling Contractor: means the employer that has overall responsibility for construction at the worksite.

Double Block and Bleed: The closure of a line, duct, or pipe by closing and locking or tagging two inline valves and by opening and locking or tagging a drain or vent valve in the line between the two closed valves.

Emergency: Any occurrence (including any failure of hazard control or monitoring equipment) or event(s) internal or external to the confined space, which could endanger entrants.

Engulfment: The surrounding and effective capture of a person by a liquid or finely divided solid (flowable) substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

Entry: The act by which a person intentionally passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

Entry Employer: Means the employer who decides that an employee it directs will enter a permit space.

Entry Permit: The written or printed document provided by the employer to allow and control entry into a permit space and contains the information specified in section (f) of the Permit-Required Confined Space standard.

- Defines the conditions under which the permit space may be entered.
- States the reason(s) for entering the space.
- Lists the anticipated hazards of the entry.
- Lists the eligible attendants, entrants, and the individuals who may be in charge of the entry.
- Establishes the length of time for which the permit may remain valid.
- Establishes special procedures, hot work permits etc., that are required to ensure safe entry and work operations.

Entry Supervisor: The person responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry. Note: An entry supervisor may also serve as an attendant or as an entrant, as long as that person is trained and equipped as required by this program for each role he or she fills. Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.

Hazardous Atmosphere: An atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to escape unaided from a permit space, injury, or acute illness from one or more of the following causes:

- Flammable gas, vapor, or mist in excess of 10 percent of its Lower Flammable Limit (LFL).
- Airborne combustible dust at a concentration that meets or exceeds its LFL.
- Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent.
- Atmospheric concentration of any substance in excess of its dose or permissible exposure limit.
- Any other atmospheric condition that is immediately dangerous to life or health.

Note: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Safety Data Sheets (SDSs), information published by government agencies (i.e., NIOSH, ACGIH, etc.) can provide guidance in establishing acceptable atmospheric conditions.

Host Employer: The employer that owns or manages the property where the construction work is taking place. Note: If the owner of the property on which the construction activity occurs has contracted with an entity for the general management of that property, and has transferred to that entity the information specified in 1926.1203(h)(1), the contracted management entity will be treated as the host employer for as long as that entity manages the property. Otherwise, the owner of the property will be treated as the host employer. In no case will there be more than one host employer.

Immediately Dangerous to Life or Health (IDLH): Any condition, which poses an immediate threat of loss of life, may result in irreversible or immediate severe health effects, may result in eye damage, irritation or other conditions which could impair escape from the permit space.

Inerting: The displacement of the atmosphere in a permit-required space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible. It is a process of rendering the atmosphere of a permit-required space non-flammable, non-explosive, or otherwise chemically non-reactive by such means as displacing or diluting the original atmosphere with steam or a gas that is non-reactive with respect to that space. Note**:** This procedure produces an IDLH oxygen-deficient atmosphere.

Isolation: The process by which a permit space is removed from service and completely protected against the release of energy and material into the space by such means as: blanking or blinding; misaligning or removing sections of lines, pipes, or ducts; a double block and bleed system; lockout or tag-out of all sources of energy or mechanical linkages.

Non-Permitted Confined Space: A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or egregious physical harm. A location that is governed by specific regulations may require special procedures to ensure all hazards are controlled before entry (i.e., telecommunications manholes or high voltage manholes).

OSC: Office Safety Coordinator.

Oxygen Deficient Atmosphere: An atmosphere containing less than 19.5 percent oxygen by volume.

Oxygen Enriched Atmosphere: An atmosphere containing more than 23.5 percent oxygen by volume.

Permit-Required Confined Space: A confined space that has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere;
- Contains a material that has the potential for engulfing an entrant;
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- Contains any other recognized serious safety or health hazard.

Permit-Required Confined Space Entry Program: The employer's overall program for controlling, and where appropriate, for protecting employees from permit space hazards and for regulating employee entry into permit spaces.

Permit System: The employer's written procedures for preparing and issuing permits for entry and for returning the permit space to service following termination of entry. Reference CP008.1.

Prohibited Condition: Any condition in a permit space that is not allowed by the permit during the period when entry is authorized.

Rescue Service: The personnel designated to rescue employees from confined spaces.

Retrieval System: The equipment (including a retrieval line, chest or full-body harness, wrist-lets, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.

Testing: The process by which the atmospheric hazards that may confront entrants of a space are identified and evaluated. Testing includes specifying the tests that are to be performed in the space. *Note*: Testing enables employers both to devise and implement adequate control measures for the protection of authorized entrants and to determine if acceptable entry conditions are present immediately prior to and during entry.

Ventilate or Ventilation: Controlling a hazardous atmosphere using continuous forced-air mechanical systems that meet the requirements of 29 CFR 1926.57 – Ventilation.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for establishing Confined Space Entry Program requirements and communicating them to the Health and Safety Network. The National Safety Director will also review the Confined Space Entry Program annually to ensure it remains effective at managing risks associated with entering confined spaces.

4.2 The TRC Health and Safety Network is responsible for Confined Space Entry Program implementation including, but not limited to:

- Serving as a Competent Person for confined space entry as needed when TRC employees are entering permit spaces.
- Assisting TRC with the identifying confined spaces at the job site.
- Providing and coordinating the required level of training for TRC employees.
- Communicating and coordinating TRC's confined space entry requirements with the applicable Host Employer(s) and Controlling Contractors.
- Procuring health and safety equipment (i.e., monitoring equipment, ventilation, hard hats, safety glasses, safety warning vests, barricade tape, harnesses, lanyards, etc.) necessary for TRC employees to safely entering permit spaces.
- Working in concert with identified Competent Person(s) to provide on-site direction on confined space entry issues.
- Performing confined space permit review in conjunction with identified Competent Person(s) and other on-site TRC subcontractor health and safety representatives.
- Maintaining records for health and safety activities on-site including confined space permits and procedural audits of employee Confined Space Entry Program implementation.

- Completing site-specific emergency contact list in the event of an incident.
- Providing assistance during emergency situations; may serve in any of the assistance roles associated with confined space entry.
- Identifying rescue services that are capable of performing confined space rescue.
- Evaluating the potential rescue team/service. **Note:** Appendix F of the OSHA 29 CFR 1910.146 Standard contains examples of criteria for evaluating the capabilities of emergency responders.

4.3 The Competent Person will work in concert with the Health and Safety Network to successfully implement the requirements of this program including the requirements listed below:

- Evaluating worksites to identify and classify permit required confined spaces.
- Approve confined space entries using the Permit to Work form CP008.1.
- Make a determination if a permit required confined space can be reclassified as a non-permit confined space. The basis for this determination must be documented on form CP008.2.
- Provide guidance for confined space entry questions.
- Observe the implementation of confined space entry and perform monthly audits regarding Confined Space Entry Program implementation.
- Be trained on the atmospheric testing equipment being used and perform testing of confined spaces.

4.4 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the Confined Space Entry Program. Project Managers must hold all site employees and subcontractors accountable for safe work practices and maintaining a safe work environment.

4.5 The Host Employer is responsible providing information regarding the permit spaces to the controlling contractor,

4.6 The Controlling Contractor is responsible for obtaining information regarding permit spaces from the Host Employer and pass it to the employer of person(s) who will be entering the permit spaces.

4.7 The Controlling Contractor is also responsible for verifying that other affected employees and employers at the worksite know not to create hazards that could create hazards to confined space entrants or hinder the rescue process.

4.8 The Entry Employer is responsible for communicating its entry program information (i.e., entry procedures, methods of controlling hazards, rescue procedures, hazards encountered that were not identified by the host employer or controlling contractor, etc.).

4.9 Entry Employers are responsible for providing the Controlling Contractor the information about their entry program and hazards they encounter in the space, and the controlling contractor passes that information on to other entry employers and back to the host. As mentioned above, the controlling contractor is also responsible for making sure employers outside a space know not to create hazards in the space, and that entry employers working in a space at the same time do not create hazards for one another's workers.

5. PROCEDURE

5.1 Identification of Confined Spaces:

- Permit-required and non-permit confined spaces shall be identified and classified during project start-up and evaluated periodically by the Health and Safety Network or other designated Competent Person.

- All employees and subcontractors shall be made aware of these confined spaces through training or instruction.

- All permit required confined space hazards will be identified with the following: "DANGER: PERMIT-REQUIRED CONFINED SPACE, UNAUTHORIZED ENTRY PROHIBITED".

5.2 Reclassification of a Permit-Required Confined Space to a Non-Permit-Required Confined Space:

- A permit-required confined space may be reclassified as a non-permit confined space if the permit space contains no actual or potential atmospheric hazard, and all other non-atmospherics hazards within the space can be eliminated without entry into the space.

- The permit-required confined space must be evaluated by the Competent Person (this person can act as the Entry Supervisor) to determine if the space meets the criteria for safe reclassification. If the space can safely be reclassified, the decision must be documented using the Confined Space Reclassification Form. Completed forms must be retained with the project file for a minimum of one year.

- The Competent Person must continuously monitor the space for new hazards. Should new hazards arise within the non-permit confined space, each employee in the confined space will immediately exit the space. The Competent Person will then reevaluate the confined space and determine whether it must be reclassified as a permit confined space.

6. MONITORING ATMOSPHERIC REQUIREMENTS PRIOR TO ENTRY

6.1. Before entering a confined space, the following atmospheric conditions must be met as TRC does not allow any employee to work where IDLH conditions are present:

- The oxygen level is between 19.5 percent and 23.5 percent.
- The concentrations of flammable gas, vapors, or mists are below 10 percent of their Lower Explosive Limits (LEL).
- The concentration of airborne combustible dust must not exceed 10 percent of the LFL.

  Note: An indication of this condition is if the dust obscures vision at a distance of 5 feet.
- The monitoring device shall be equipped with an audible and visible warning device that warns the entrant and/or attendant of the hazardous atmosphere in the permit space.
- Air monitoring devices shall be calibrated relative to the oxygen content of the ambient air at the time of sampling. Calibration of the monitoring device relative to the oxygen content shall be performed where the 20.9 percent natural content of oxygen in the air is most likely to occur.
- Calibration of a sampling device shall be conducted as often as recommended by the manufacturer, but at least once every year.
- Non-sparking Equipment: When sampling the atmosphere of a confined space, the monitoring device shall have an attached non-sparking probe.
- Intrinsically Safe: When the confined space to be entered is expected to have combustible vapors present, employees shall be required to use an approved explosion-proof or intrinsically safe monitoring device.
- The atmosphere in the confined space within the entrant's immediate area shall be continuously monitored for oxygen and other atmospheric contaminants which are believed to be present in the confined space. Atmospheric monitoring must be conducted by a person trained on the proper use, calibration and limitations of the atmospheric monitoring equipment.
- When monitoring for entries involving a descent or ascent into atmospheres that may be stratified, the atmospheric envelope should be tested at a distance of approximately four feet in the direction of travel and to each side.
- Stratified testing should be performed prior to entering the space and continuously while performing work due to atmospheres in the confined space that could change due to different specific gravities of the gases/vapors.

- Prior to entering the space, tests should be performed at the top, middle, and bottom sections of entry space. If a sampling probe is used, the monitoring device's rate of progress should be slowed to accommodate the sampling speed and detector response.

6.2. Achieving Safe Atmospheres:

- In order to achieve and maintain a safe atmosphere, one or more actions may have to be taken to render the space safe for human occupancy. This could include:
  - Isolation—precautions taken to prevent release of material and/or energy into the space. This can be achieved through blinding, blanking, disconnecting, lockout/tagout (LOTO), or removal of incoming pipes or related energy sources.
  - Separation—where there is a possibility of external hazards, the space may require barricades to protect the entrants from falling objects or from unauthorized entry.
  - Depending on the confined space, there may be residual hazards that could present a hazard to the entrant. These residuals hazards should be characterized and safely removed from the space prior to entry. Contact a person that has knowledge of the confined space and its contents, refer to the safety data sheet and tank/pipe labels to identify the potential residual hazards. Examples of residual hazards include chemical residue, solid deposits, and hot/cold surfaces.

6.3. Ventilation:

- If a confined space being entered is found to contain a hazardous atmosphere, forced air ventilation may be provided for a period of time in order to bring the air quality within the acceptable limits. Once the determined ventilation period expires, employees shall monitor the confined space prior to entry. If the sampling shows that a hazard still exists, then additional ventilation and sampling may be required.

- Control of atmospheric hazards through forced air ventilation does not constitute elimination of hazards.

- If the hazard still exists after repeated ventilation steps, the confined space shall then be considered a permit-required confined space and the Confined Space Entry Team (entrant, attendant, and Confined Space Entry Supervisor) must follow the proper procedures for permit-required confined space entry.

- Forced air ventilation should be so directed as to ventilate the immediate areas where an employee is or will be present within the space and shall continue until all employees exit the space.

6.4. Whenever ventilation is used, employees shall:

- Keep the blower controls at least 10 feet from the confined space, and out of the wind or downwind from the entrance to the confined space.
- Use a ventilation blower that is designed to be intrinsically safe if the possibility of an explosive atmosphere could exit.
- Ensure that the exhaust systems are designed and placed so that they protect employees in the surrounding area from being contaminated.
- Ensure that the ventilation system is fully operational and air is supplied from a clean source.
- Ensure that contaminated air is not recirculated back into the confined space.
- Purge the ventilation hose outlet for at least one minute (at street level if possible) before inserting the hose into the confined space.
- Maintain continuous local ventilation when toxic atmospheres are being produced as part of a work procedure (i.e., welding, painting or cleaning operations).

6.5. Inert Gases:

- Inert gases, such as nitrogen, argon, and helium, are non-toxic, odorless, and tasteless gases that do not support human breathing and react scarcely or not at all with other substances. Inert gases are difficult to detect and can displace oxygen inside a confined space, therefore making the atmosphere inside the space hazardous. It is therefore absolutely essential to draw the attention of employees and contractors to the hazards of inert gases and oxygen depletion.

6.6. Extreme Temperatures:

- Prolonged exposure to extreme temperatures (hot or cold) can be dangerous. The effects of exposure to extreme temperatures can be increased by several factors including the amount of work (e.g., calorie expenditure) a person is performing, additional clothing (e.g., welding jacket, gloves, etc.), and personal protective equipment (PPE) (e.g., respirator).
- Hazards associated with extreme temperatures and the symptoms (e.g., heat stroke, hypothermia, etc.) must be understood by all employees that are involved with the confined space entry. It is also important to understand that every person has a unique tolerance to temperate extremes. Refer to TRC's Health Illness Prevention Program CP011.

7. PERMIT-REQUIRED CONFINED SPACE ENTRY

7.1 All employees required to enter into a confined or enclosed space shall be informed of the hazards involved, the necessary precautions to be taken, and in the use of PPE and emergency equipment required through tailgate meetings and danger signs posted at the job location.

7.2 Authorized Entrants:

- Authorized Entrants must know how to:
  - Use required equipment to ensure safe entry.
  - Maintain constant communication with attendants.
  - Alert attendants when warning signs or other hazardous conditions exist; and
    - Exit as quickly as possible whenever ordered or alerted (by alarm, warning sign or prohibited condition) to do so.
  - Understand the hazards they may face, be trained to recognize signs or symptoms of exposure, and understand the consequence of exposure to hazards.
  - Continuously monitor for atmospheric hazards and engulfment hazards while inside the space and evacuate the space immediately if hazards arise.

7.2.1 Attendant:

- Attendant(s) may only be assigned to a single designated confined space. The attendant shall not monitor more than one space at a time.
- Attendant(s) may not perform any duty that will interfere with their primary duties, which include, but are not limited to:
  - Check permits of authorized entrants.
  - Prevent unauthorized entry in permit-required confined spaces.
  - Maintain a continuous count of those in a confined space, by utilizing a sign-in and sign-out form.
  - Monitor activity in the confined space and continuously monitor for engulfment hazards as possible from outside the space.
  - Perform intermittent or continuous air monitoring.
  - Remain outside the confined space until relieved.
  - Trained and certified in Cardiopulmonary Resuscitation (CPR)/First Aid.
  - Understand the hazards of a confined space and being aware of potential exposures.
  - If necessary; ordering all employees to exit a confined space.
  - Contact rescue team.
  - Perform non-entry rescue.

7.2.2 Entry Supervisor:

- Entry supervisors must know the hazards of confined spaces and must verify that all tests have been conducted and all procedures and equipment are in place before endorsing a permit. The Entry Supervisor must also verify that a rescue plan is in place and the designated rescue team has been notified prior to the entry.
- Entry Supervisors are also responsible for the following:
  - Participate in and verify that a risk assessment has been conducted for the task prior to approving entry.
  - Communicate the hazards and safety precautions associated with the confined space.
  - Ensure that all equipment that is necessary for the safe entry and exit of permit-required confined space is available and maintained in good working condition.
  - Identify and evaluate potential confined space hazards.
  - Verify emergency response plans prior to allowing entry.
  - Approve and cancel entry permits; and review canceled permits to ensure the permit was effective.
  - Authorize entry into confined space.
  - Terminate or suspend the confined space entry and permit when the work covered by the confined space permit has been completed or when a hazardous condition arises in or near the confined space.
  - Remove the entry permit from the confined space for proper record retention after the permit has been terminated.
  - Confirm all personnel are accounted for upon termination of the entry permit.
  - Ensure entry operations are consistent with entry permit.
  - Revalidate and resign the entry permit when there is a change in roles.
  - Prevent unauthorized entry in to permit-required confined spaces.
  - Ensure the rescue service has been notified of the intended entry and is committed to providing rescue services when summoned.
  - Debrief the host employer or the controlling contractor about any hazards or deficiencies that developed during the entry.

8. CONFINED SPACE EQUIPMENT

8.1 In order to perform safe entry, exit, and non-entry rescue of permit-required confined spaces, the site must maintain the following equipment:

- Direct read atmospheric testing equipment;
- Ventilating equipment, if necessary;

- Communications equipment (e.g., two-way radio);
- PPE which has been identified as necessary for both entry and rescue;
- Lighting equipment that is designed for confined spaces, allowing for both safe work, exit and rescue if necessary;
- Barriers or other devices necessary for protecting workers from external hazards;
- Equipment necessary for safe entry and exit (e.g., ladders); and
- Non-entry rescue and emergency equipment including first aid supplies.

9. EMERGENCY RESCUE

- Only non-entry rescues will be permitted by TRC personnel. Only trained emergency responders are permitted to enter confined spaces to perform rescue duties.

- Rescue services must be identified, evaluated and available for all permit-required confined space entries, except for vertical entries where non-entry rescue offers the safest approach. Rescue teams can be comprised of on-site or outside personnel; however, they must be able to meet and comply with the requirements of this program and must be able to perform rescue within four minutes of being summoned for rescue.

- If local rescue services, such as the fire department, are identified as the rescue team, an evaluation must be made to verify the rescue service is available and capable of performing the rescue. This evaluation should be documented. In addition, the local rescue service must be informed of the entry schedule prior to employees entering the permit space.

- Rescue teams must be made aware of the nature and type of hazards within permit spaces and must be provided access to the permit spaces prior to work being performed in order to develop rescue plans and practice rescues. The Health and Safety Network or designated Competent Person(s) must contact rescue teams prior to permitting entry into a permit-required confined space. Rescue services will be called in the event of any emergency involving confined space, and must have training equivalent to the potential situations in which they may be required to assist. The entry supervisor will be responsible for contacting the rescue team. If outside services are used as primary or secondary rescue, the entry supervisor shall communicate with the rescue team, prior to entry, to ensure that they are aware of the intended entry and are available to perform rescue. These steps shall be documented on the Confined Space Entry Permit.

- The minimum requirements for rescue teams are as follows:
  - o Rescuers are to be qualified as authorized entrants for the confined space in which work is being performed.
  - o Rescue personnel will practice making permit space rescues at least once every 12 months, by means of simulated rescue operations from the actual permit spaces or from representative permit spaces. Representative permit spaces must simulate the actual permit space being entered, with respect to opening size, configuration, and accessibility.
  - o Rescue personnel will be trained and certified in First Aid/CPR.
  - o Rescue personnel are to be equipped with, and trained to use, PPE and rescue equipment necessary to enable them to enter and perform rescue operations in the permit-required confined space.

- For non-entry rescue, the authorized entrants must:
  - o The entrant(s) shall don a full body harness with a retrieval line attached at the center of back, near the shoulder level or above the entrant's head.
  - o Attach the other end of the retrieval line to a mechanical device of fixed point outside the confined space in such a manner that rescue can begin as soon as the rescuer becomes aware that rescue is necessary.
  - o Set up a mechanical device and make it ready to retrieve personnel from vertical type confined spaces more than 5 feet deep.

10. ENTRY PERMITS

- Before entry into a permit required confined space is authorized, a permit to work (CP008.1) shall be prepared in order to document the completion of safety measures required. The completed permit shall be made available to all authorized entrants at the time of entry by posting the permit at the entry portal or by other equally effective means.

- The Entry Supervisor shall ensure that the permit has been satisfactorily completed, including the procedure for contacting rescue services.

- A fully completed entry permit shall be signed by the Entry Supervisor to authorize entry into a permit-required confined space.

- Conditions that prohibit entry to a confined space will be evaluated and listed on the entry permit.

- The permit shall be dated and carry an expiration time limiting the work to one shift. The permit must be revalidated and resigned if a role change occurs.

- The duration of the permit may not exceed the time required to complete the assigned task or job identified on the permit.

- The permit must be posted at the entrance to the confined space.

- The Entry Supervisor shall terminate the work in the confined space if an unsafe condition develops which exceeds the conditions authorized on the permit or when the entry has been completed.

- The entry permit status shall be updated to reflect the cancelled status and also the summary of the unsafe condition.

- Cancelled entry permits will be reviewed for effectiveness, and retained in the TRC project file for at least one year.

- A review of entry operations and procedures will occur any time there is reason to believe employees are not adequately protected under this program. Revisions to this program will be made prior to subsequent entries if deficiencies are found to exist.

11. TRAINING

- All project employees will receive documented training during site-specific orientation regarding TRC's requirements involving work with confined space entry hazards.

- Additional training for employees who will perform confined space entry procedures will be provided during site-specific Health and Safety Training, or prior to starting the project. Refresher training is necessary when duties change, hazards change, or evaluation determines inadequacies in an employee's knowledge.

- Training on TRC's LOTO Program and PPE Program is also required for employees involved with confined space entry where these hazards are present.

- The entry supervisor will ensure that all persons involved with the confined space entry will be trained and tested as necessary. He/She is to give training that ensures understanding, knowledge, and skills necessary for the safe performance of their assigned duties.

- Training will be given at the following times:
  - Prior to any new employee being assigned confined space duties;
  - Before there is a change in assigned duties; and
  - Whenever the entry supervisor has reason to believe that there are deviations from the permit space entry procedures or that there are inadequacies in the employee's knowledge or use of these procedures.

- The training requirements for entrants/attendants/ and entry supervisor will include:
  - Hazard recognition,
  - Symptoms of overexposure,
  - PPE,
  - External hazards,
  - Review of the confined space permit,
  - Air monitoring equipment and procedures,
  - Non-entry rescue equipment and procedures, and
  - Contacts to be made in event of an emergency.

12. REFERENCES/RELATED DOCUMENTATION

29 CFR 1910.146 – Permit Required Confined Spaces

29 CFR 1910.147 – The Control of Hazardous Energy

29 CFR 1926 Subpart AA - Confined Spaces in Construction

CP002 – Risk Analysis/Site-Specific Health and Safety Program

CP003 – Personal Protective Equipment Program

CP005 – Lockout/Tagout Program

CP008.1 Permit to Work

CP008.2 Confined Space Reclassification Form

CP0011 Health Illness Prevention Program

13. RECORDS

Completed Permit to Work forms

Completed Confined Space Reclassification forms

Project Name: ______________________ Project No. ____________

Location: ______________________ Date: ____________

Company: ______________________

Submitted By: ______________________

☐ **Hot Work**	☐ **LOTO**	☐ **Confined Space**	☐ **Excavation**	**Equipment Used**	**Hot Work**
Task/Job to be Performed/Reason for Entry (Describe in Detail)					☐ Welder
					☐ Torch
					☐ Grinder
					☐ Abrasive Saw
					☐ Open Flame
Start Date: ____________	End Date: ____________	Time From: ____________	Time To: ____________		
Other Approvals: ☐ Fibers Assessment ☐ Lead Survey ☐ Critical Lift ☐ Live Electrical ☐ Hot Tap ☐ Crane Basket					

ISOLATION – LOTO

Type of Energy: ☐ Electrical ☐ Mechanical ☐ Pressurized Gas/Liquid ☐ Gravity ☐ Radiation ☐ Other:

Is Equipment Isolated? ☐ Yes ☐ No ☐ N/A If yes, how? _____

Is Equipment: ☐ Depressurized ☐ Neutralized ☐ Opened ☐ Cleaned ☐ Drained ☐ Purged ☐ Other:

Equipment Previously Contained:

Equipment Still Contains Residual:

Area Isolation: ☐ Equipment in Service ☐ Barricades ☐ Signs ☐ N/A ☐ Other:

HOT WORK

Is equipment isolated and internal atmosphere tested 10% LEL or less? ☐ Yes ☐ No = Deny permit ☐ N/A

Atmosphere tests performed at fire work site and surrounding area indicate10% LEL or less? ☐ Yes ☐ No = DENY PERMIT

Is surrounding area free of material / residue that may be ignited by fire work (20 feet)? ☐ Yes ☐ No

Controls: _____

Is a fire watch needed? ☐ Yes ☐ No If yes how many? Location:

Is a fire extinguisher needed? ☐ Yes ☐ No If yes how many? Location:

CONFINED SPACE

Type: ☐ **Permit Required Confined Space** (Contains hazardous atmosphere, potential engulfment, trapping internal configuration, or any serious safety or health hazards.)

☐ **Reclassified Confined Space** (Complete Reclassification form CP008.2)

Date/Time Safety notified of Permit Required Confined Space entry: _____ ☐ N/A

Ventilation method: ☐ Forced ☐ Local Exhaust ☐ Natural Draft ☐ N/A

Communication Method: ☐ Voice Contact ☐ Hand Signal ☐ Two-Way Radio Channel: _____ ☐ Air-Horn ☐ Other

Is retrieval equipment required? ☐ Yes ☐ No Type: _____

Continuous air monitoring required? ☐ Yes ☐ No Periodic air monitoring required? ☐ Yes ☐ No

Special Lighting required? ☐ Yes ☐ No Type: _____

Emergency Rescue Service: _____

Attendant Signature: Entry Supervisor: Competent Person:

ATMOSPHERE

Time	Location	Oxygen 19.5-23.5%	Flammability < 10% LEL	H2S < 10 ppm	CO < 35 ppm	Other (Specify)	Initials

EXCAVATIONS

Competent Person: Location:

Size of Trench: Length _____ Width _____ Depth _____ Sketch or Drawing Attached: ☐ Yes ☐ No

Existing Utilities: ☐ Electrical ☐ Telephone ☐ Water ☐ Sewer ☐ Steam ☐ Alarm ☐ Drain ☐ Process ☐ Other

Other Known Obstructions: ☐ Footings ☐ Pilings ☐ Concrete Encasements ☐ Other

Contact Local Authorities? ☐ Yes ☐ No If yes, who and when? _____

Extra Precautions: ☐ De-energize Lines ☐ Ground Equipment ☐ Insolate Operator ☐ Hand Excavate ☐ Other

Soil Classification: ☐ Type A ☐ Type B ☐ Type C ☐ Solid Rock Test Used:

Protective System:	Drawing Number(s) Referenced:
☐ Sloping _____ vertical (ft.) _____ horizontal (ft.) ☐ Benching _____ vertical cut (ft.) _____ horizontal cut (ft.) ☐ Shoring Type: _____ ☐ Shield Type:	

The above data has been checked with blueprints on file. When close clearances are indicated, hand excavation must be used to determine the exact location. Existing lines and interference's, in the vicinity of work, must be marked by stakes indicating location and depth prior to excavating.

Other

Additional Safety Precautions/Hazards:

Signatures

Permit Issued By:		Phone #:		Time Issued:	
Permit Issued To:		Phone #:		Time Received:	
Extended By:		Phone #:		Extended To:	

Work Completed: ☐ Yes ☐ No Supervisor Signature:

Persons Covered by this Permit	Covered by Group LOTO? (Initials)	Group LOTO Complete (Initials)	Confined Space Entrant	Time of Entry/Exit							
				In	Out	In	Out	In	Out	In	Out
			☐								
			☐								
			☐								
			☐								
			☐								
			☐								
			☐								
			☐								
			☐								

Confined Space Reclassification Form CP008.2

Location of Confined Space (be specific): ____

Description of work activity: ____

____

Answer the following questions to determine if the permit-required confined space can be reclassified as a "non-permit space" considered for reclassification to a non-permit confined space. If any of the questions below are answered YES, the space cannot be reclassified.

NOTE: The hazards must be eliminated without entry to be considered a non-permit confined space.

1) Atmospheric conditions: (Circle One)

- Is there a potential for an oxygen deficient or oxygen enriched atmosphere caused by oxidation, bacterial action, combustion, use of inert gases, leaking, pipes? YES NO
- Is there a potential for harmful air contaminants to be present? YES NO
- Is there a potential for an explosive or flammable atmosphere (residues, bacterial action, leaking pipes, hoses, reactions with acids or metals, painting and cleaning, residual dusts)? YES NO
- Will work performed in or around the space create a hazardous atmosphere? YES NO
- Will hazardous materials be brought into the confined space? YES NO
- Will residue from the hazardous material remain in the space? YES NO
- Will additional measures, other than mechanical ventilation, be needed to control the hazardous atmosphere? YES NO

2) Are there any other safety hazards that cannot be eliminated without entry into the space? Examples of potential hazards include: YES NO

- Electrical, unsecured objects, mechanical, biological, gases or fluids under pressure.

3) Atmospheric testing

Record all atmospheric testing data on below:

TEST	LIMITS	TIME	ACTUAL READING
Oxygen	19.5% to 23.5%		
Lower Flammable Limit (LFL)	Under 10%		
Carbon Monoxide (CO)	Less than 35 ppm		
Hydrogen Sulfide	Under 7 ppm		
Other:			

I certify that all known or potential hazards have been appropriately eliminated prior to entry into the above confined space, thereby allowing for the reclassification of the space as a Non-Permit Confined Space:

Reclassification Authorized By (Competent Person): ____

Date: ____

Reclassification status may be maintained only for the duration of the ENTRY, as long as the hazards remain eliminated.

1. PURPOSE

This Heat Stress Program has been developed to reduce the risk of heat related illness to TRC employees while working outdoors or in buildings without climate control. This program outlines the responsibilities and process for preventing heat-related illnesses and intervening if a person develops symptoms of heat stress. This program is available to all employees through TRCNET.

2. SCOPE

The program applies to all part- and full-time TRC employees.

3. DEFINITIONS

Acclimatization: Means temporary adaptation of the body to work in the heat that occurs gradually when a person is exposed to it. Acclimatization peaks in most people within four to fourteen days of regular work for at least two hours per day in the heat.

Heat Stress: A physiological condition induced when high temperatures and humidity compromise the body's ability to cool itself, resulting in heat-related illnesses ranging in severity from mild (including heat cramps and heat rash), to moderate (heat syncope and heat exhaustion), to life threatening (heat stroke).

Heat Rash: A mild form of heat rash characterized by red papules usually appearing where clothing is restrictive.

Heat Cramps: Painful muscle contractions caused by consuming insufficient liquid when working in hot environments.

Heat Syncope: Fainting caused by standing in one position for a prolonged period of time in hot environments.

Heat Exhaustion: Heat stress characterized by headache, vertigo, weakness, thirst, and giddiness. Heat exhaustion, if left untreated, can progress rapidly to heat stroke.

Heat Stroke: A life-threatening form of heat stress characterized by a high body temperature (over 104° F), hot, dry skin, rapid heart rate, dizziness, shivering, nausea, irritability, mental confusion, convulsions, unconsciousness, and perhaps death.

High Risk Environments: Work environments where workers are routinely exposed to temperatures above 80 degrees Fahrenheit and often humid working conditions, putting them at increased risk for heat stress disorders.

Potable Water: Water that is fresh, pure, suitably cool, and provided to employees free of charge. One quart per employee per hour, for the entire shift, should be available.

Severe Risk (high-heat) Environments: Work environments where workers are routinely exposed to temperatures above 95 degrees Fahrenheit and often humid working conditions, putting them at risk for heat stress disorders.

4. RESPONSIBILITIES

4.1. The National Safety Director administers the Heat Stress Program for TRC.

4.2. TRC's Safety Network is responsible for providing guidance to Project Managers and Superiors on selecting appropriate safety precautions based on the project-specific risk factors.

4.3. Project Managers are responsible for the following:

- Assessing the heat related risks associated with a project during the planning phase. The risk factors listed in this program shall be considered when performing the risk assessment.
- Confirming that sufficient potable water is available at project sites, most importantly at sites where employee will be working in high risk environments.
- Confirming that employees who are working on project sites in high-risk environments have access to shade.

4.4. Office Safety Coordinators are responsible for assisting the project manager in developing the site-specific Health and Safety Plan (HASP), and assuring that appropriate Personal Protective Equipment (PPE) is available for employees.

4.5. A TRC Industrial Hygienist may be asked to evaluate specific tasks/environments and take measurements to determine the level of risk for a given area.

4.6. TRC Employees are responsible for the following:

- Informing TRC Project Managers and Supervisors of personal risk factors that may increase their risk to heat related disorders.
- Following safety precautions that have been determine appropriate for the project.
- Communicating early symptoms of heat stress to a coworker or project managers as soon as the symptoms are recognized.

5. PROCEDURE

5.1. Hazard Assessment

Project Managers and Supervisors shall assess project work during the planning phase for risk factors that can cause heat stress to TRC employees. There are four key risk factors that can affect the heat stress in the workplace, which are listed below. These risk factors will be managed to reduce the heat stress to employees working in high risk and severe risk environments.

5.1.1.Environmental conditions

- Temperature;
- Humidity; and
- Air movement.

5.1.2.Hot surfaces (machines, ovens, engines, etc.).

5.1.3.Physical activity (i.e., metabolic rate)

- Rest - Sitting
- Light - Sitting with light manual work with hands or hands and arms, and driving. Standing with some light arm work and occasional walking.
- Moderate - Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling. Normal walking.
- Heavy - Intense arm and trunk work, carrying, shoveling, manual sawing; pushing and pulling heavy loads; walking and fast pace.
- Very Heavy - Very heavy activity at fast to maximum pace.

5.1.4.Clothing/PPE (e.g., Tyvek suit, flame resistant clothing, gloves, respirator, etc.)

5.1.5.Personal factors

- ability to acclimatize to hot environments;
- medical conditions;
- increasing age;
- overall level of fitness;
- presence of other metabolically stressful illnesses;
- use of certain medications;
- dehydration; and
- alcohol intake.

5.2. Based on this assessment, appropriate safety precautions shall be identified and implemented to minimize the risk of heat stress. When employees are exposed to multiple risk factors, the safety precautions should be increased. When there is uncertainty of the potential risk of heat stress, a quantitative exposure assessment can be performed by an industrial hygienist.

5.3. There are two primary methods for measuring and characterizing heat index levels in the workplace. One method compares the Wet Bulb Globe Temperature to the Threshold Limit Values (TLVs) for Heat Stress and Heat Strain published by the American Conference of Governmental Industrial Hygienists (ACGIH). The second method compares the temperature and humidity to the National Oceanographic and Atmospheric Administration (NOAA) Heat Index values.

5.4. The hazard assessment and safety precautions should be listed in the site-specific health and safety plan and communicated to the affected employees.

5.5. Project Managers and Supervisors shall consider one or more of the following safety precautions as necessary to minimize the risk of heat stress to employees. Personal risk factors should also be considered when selecting and implementing safety precautions.

5.6. Safety Precautions

The following safety precautions that can be used to reduce the risk of heat stress to workers. The extent and number of safety precautions shall be proportionate to the heat index in the working environment.

5.6.1. Ventilation – Where available, general ventilation (fans) can be provided. This should result in increased cooling of the body by increasing the convective heat loss and the sweat evaporation heat loss.

5.6.2. Air Conditioning – Vehicles and buildings are often equipped with air conditioning. When possible employees should be provided rest periods in air conditioning to reduce the risk of heat stress.

5.6.3. Acclimatization – An employee can best adapt to heat by being in the hot environment initially for very short periods, then longer periods. Acclimatization may take several days or longer, depending upon all the factors listed above. Acclimatization must be repeated if the employee is off work for an extended period or has been ill.

5.6.4. Hydration – Employees shall have access to potable water, starting at the beginning of the workday. Employees may begin the shift with smaller quantities of water if effective procedures for replenishment of water during the shift have been implemented to provide employees one quart or more per hour. Employees must also have multiple opportunities to consume the liquids throughout the workday.

5.6.5. Shade – Shade that is either open to the air or provided with ventilation shall be available as close to workers as practical whenever there is a risk of heat stress, or the temperature reaches 80 degrees Fahrenheit. Employees who need a cool-down period to avoid developing heat stress symptoms shall be provided access to shade. Shade areas must be able to comfortably accommodate all TRC employees who desire a cool-down period, and also the maximum number of TRC employees taking a meal break simultaneously.

Shade can include trees, buildings, canopies, lean-tos, or other partial and/or temporary structures that are either ventilated or open to air movement. The interior of cars or trucks are not considered shade unless the vehicles are air conditioned or kept from heating up in the sun by another method.

5.6.6. Communication and Observation – Employees working in severe risk (high-heat) work environments must maintain continual communication with coworkers. This can be accomplished verbally of via cellular telephones.

5.6.7. Limiting exposure time – Work schedules should be designed to limit the employees' time spent in high risk and severe risk environments (for example, scheduling outdoor work during the cooler hours of the day).Work breaks must provide employees with an opportunity to move to a cooler environment.

5.6.8. Appropriate clothing – Whenever possible, clothing provided to workers in hot environments should be permeable to air and loose fitting. Less clothing is not necessarily a viable option due to possibility of radiant heat burns or sunburn or work hazards (i.e., flammable/combustible liquids, electrical hazards, etc.).

5.6.9. Auxiliary Body Cooling – For employees who must work in areas at high risk for causing heat stress, commercially available cooling vests and other personal protective equipment are available and should be considered.

5.7. For work environments that have severe risk (above 95 degrees F), the following safety precautions must be implemented:

5.7.1. Communication and Observation – Employees working in severe risk (high-heat) work environments must maintain continual communication with coworkers. This can be accomplished verbally of via cellular telephones.

5.7.2. Emergency Coordinator – One or more employees and the worksite shall be designated as the emergency coordinator. The coordinator will be provided a cellular phone and authorized to call for emergency medical services (following the Site-specific Health and Safety Plan) if an employee experiences significant heat stress symptoms.

5.7.3. Hydration Reminders – The Project Manager or Site Supervisor shall periodically remind employees of the importance to consume water, even if they're not thirsty.

5.7.4. Tailgate meetings – During the pre-shift meeting, employees shall be reminded of the symptoms associated with heat stress, the importance to stay hydrated, and the requirement to follow safety precautions identified by the Project Manager and/or Site Supervisor.

5.8. Heat Stress Disorders/Symptoms and First Aid Measures

5.8.1. Employees and Project Managers shall be knowledge on the following heat disorders, the associated symptoms and the appropriate first aid / medical attention.

5.8.2. If an employee exhibits symptoms of heat stress, or if symptoms are observed by a coworker, the appropriate first aid/ medical attention listed in the following tables should be provided.

Heat Disorder	Symptoms	First Aid / Medical Attention
Heat Stroke Heat stroke occurs when the body becomes unable to control its temperature and the body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Heat stroke can cause death or permanent disability if emergency treatment is not given.	▪ Hot, dry skin or profuse sweating ▪ Hallucinations ▪ Chills ▪ Throbbing headache ▪ High body temperature ▪ Confusion/dizziness ▪ Slurred speech	▪ Call 911. ▪ Move the person to a cool shaded area. ▪ Cool the person using methods such as: — Soaking their clothes with water. — Spraying, sponging, or showering them with water. — Fanning their body.
Heat Exhaustion Heat exhaustion is the body's response to an excessive loss of water and salt, usually through excessive sweating.	▪ Heavy sweating ▪ Extreme weakness or fatigue ▪ Dizziness, confusion ▪ Nausea ▪ Clammy, moist skin ▪ Pale or flushed complexion ▪ Muscle cramps ▪ Slightly elevated body temperature ▪ Fast and shallow breathing	▪ Have person rest in a cool, shaded or air-conditioned area. ▪ Have them drink plenty of water. ▪ Have them take a cool shower. ▪ Medical approval required to return to work.

Heat Disorder	Symptoms	First Aid / Medical Attention
Heat Syncope Heat syncope is a fainting (syncope) episode or dizziness that usually occurs with prolonged standing or sudden rising from a sitting or lying position. Factors that may contribute to heat syncope include dehydration and lack of acclimatization.	▪ Light-headedness ▪ Dizziness ▪ Fainting	▪ Sit or lie down in a cool place when they begin to feel symptoms. ▪ Slowly drink water, clear juice, or a sports beverage. ▪ Obtain medical approval to needed to return to work.
Heat Cramps Heat cramps usually affect workers who sweat a lot during strenuous activity. This sweating depletes the body's salt and moisture levels. Low salt levels in muscles causes painful cramps. Heat cramps may also be a symptom of heat exhaustion.	▪ Muscle pain or spasms usually in the abdomen, arms, or legs.	▪ Stop all activity, and sit in a cool place. ▪ Drink clear juice or a sports beverage. ▪ Do not return to strenuous work for a few hours after the cramps subside because further exertion may lead to heat exhaustion or heat stroke. ▪ Seek medical attention if any of the following apply: — The worker has heart problems. — The worker is on a low-sodium diet. — The cramps do not subside within one hour.

Heat Disorder	Symptoms	First Aid / Medical Attention
Heat Rash Heat rash is a skin irritation caused by excessive sweating during hot, humid weather.	▪ Heat rash looks like a red cluster of pimples or small blisters. ▪ It is more likely to occur on the neck and upper chest, in the groin, under the breasts, and in elbow creases.	▪ Try to work in a cooler, less humid environment when possible. ▪ Keep the affected area dry. ▪ Dusting powder may be used to increase comfort.

Source: Center for Disease Control and Prevention (CDC)

5.9. Training:

Training is a critical element of heat stress prevention. All supervisors and employees must be trained in 1) the recognition of the signs and symptoms of impending heat illness, 2) the heat stress prevention methods that can reduce the risk of heat disorders, and 3) the basic First Aid procedures for heat stress symptoms. Supervisors will receive this training prior to supervision of employees.

At a minimum, heat stress prevention training will include the following topics:

- Health hazards related to heat stress.
- TRC's procedures for identifying, evaluating and controlling exposures to the environmental and personal risk factors for heat illness.
- Recognition of predisposing factors, danger signs, and symptoms.
- The importance of immediately reporting symptoms or signs of heat illness in themselves to the Project Manager, the Site Employee(s) or Work Care.
- Procedures for responding to symptoms of possible heat illness, including how emergency medical services will be provided should they become necessary.

6. REFERENCES/RELATED DOCUMENTATION

NIOSH Research Report, Relationships Between Several Prominent Heat Stress Indices, 1976 Jensen & Heins.

Occupational Exposures to Hot Environments, NIOSH Revised Criteria, 1986.

ACGIH TLV & Biological Exposure Indices for 2007, ACGIH.

Beshir, M.Y., A Comprehensive Comparison Between WBGT and Botsball, American Industrial Hygiene Association Journal, February 1981.

OSHA Technical Manual: Heat Stress (Directive Number: TED 01-00-015), 1999

Memorandum: Extreme Heat-Related Outdoor Inspections, OSHA Memo, July 2012

7. APPENDICES

Appendix A: Heat Index Table

APPENDIX A

Having awareness of heat illness symptoms can save your life or the life of a co-worker. The following table provides valuable information concerning heat-related illnesses and the level of safety precautions that should be implemented.

HEAT INDEX TABLE

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Index	Risk Level	Protective Measures
Less than 91°F	Lower (Caution)	Basic heat safety and planning
91°F to 103°F	Moderate	Implement safety precautions and heighten awareness
103°F to 115°F	High	Additional safety precautions to protect workers
Greater than 115°F	Very High to Extreme	Triggers even more aggressive safety precautions

1. PURPOSE

This Cold Stress Program has been developed to proactively prevent TRC employees from developing cold-related illness and injury.

The Cold Stress Program is designed to:

- Inform employees about potential hazards associated with working in a cold environment.
- Provide guidelines for recognizing symptoms of cold-related illnesses ranging from hypothermia to frostbite.
- Prevent employee injuries and illnesses caused by cold stress.
- Comply with all applicable federal and state regulations.

2. SCOPE

The program applies to all part- and full-time TRC employees, and will help to identify Primary Factors or Environmental Factors:

- Certain medications may prevent the body from generating heat normally. These medications include antidepressants, sedatives, tranquilizers, and heart medications.
- Medical conditions can also increase the risk of cold stress. These include heart disease, asthma/bronchitis, diabetes, and vibration/white finger disease.
- Low temperatures.
- Cool high wind.
- Dampness.
- Cold water.

3. DEFINITIONS

Frostbite: The freezing or the local effect of partial freezing of some part of the body. High surface-area-to-volume ratios such as the fingers, toes, ears, nose, and cheeks are most susceptible to frostbite.

Hypothermia: A severe drop in core body temperature due to overexposure to low temperatures.

Trench Foot: Caused by having feet exposed to wed cold environments or immersed in cold water for long periods of time. Victims will generally complain of tingling, itching or burning sensations and blisters may form in affected areas.

Wind Chill: A measure of the rate of heat loss from exposed skin caused by the combined effects of high winds and low temperatures. The wind chill temperature is what the temperature “feels like” during cold weather as a result of the wind. As the wind increases, it draws heat from the body temperature.

4. RESPONSIBILITIES

4.1. The National Safety Director administers the Cold Stress Program for TRC.

4.2. The Project Manager will be provided a copy of this program and is responsible for assessing the risks of a project including identification of when cold stress prevention measures may be required.

4.3. Office Safety Coordinators are responsible for assisting the Project Manager in developing the Site-Specific Health and Safety Plan (HASP), and assuring that appropriate Personal Protective Equipment (PPE) is available for employees.

4.4. A TRC Industrial Hygienist may be asked to evaluate specific tasks/environments and take measurements to determine the level of risk for a given area.

4.5. TRC Employees are responsible for reviewing and complying with the program.

5. PROCEDURE

When working in cold environments, most of the body's energy is used to maintain the internal body temperature. This is done by reducing heat loss and increasing heat production. Under cold conditions, blood vessels in skin, arms and legs constrict, decreasing blood flow. Over time, the body will shift blood flow from the extremities and skin to the core. This allows exposed skin and extremities to cool rapidly and increases the risk of frostbite and hypothermia. Trench foot or immersion foot occurs when feet are cold and damp while wearing constricting footwear. Unlike frostbite, immersion foot does not require freezing temperatures and can occur in temperatures up to 60° F. The condition can occur with as little as eleven hours of exposure.

The following table identifies each condition, the signs and symptoms, and recommended First Aid:

Cold Stress Disorders

Condition	Signs and Symptoms	First Aid
Mild Hypothermia Usually occurs when the core body temperature drops between 98 - 90°F.	• Shivering; • Lack of coordination, stumbling, fumbling hands; • Slurred Speech; • Memory Loss; and/or • Pale, cold skin.	• Move to warm area; • Stay active; • Remove wet clothes and replace with dry clothes or blankets and cover head; and/or • Drink a warm (not hot) sugary drink.
Moderate Hypothermia Usually occurs when the core body temperature drops between 90 - 86°F.	• Shivering stops; • Unable to walk, to stand; and • Confused and irrational.	• All of the above plus: • Call 911 for an ambulance; • Cover all extremities; completely; and • Place very warm objects, such as hot packs or water bottles on the victim's head, neck, check and groin.
Severe Hypothermia Usually occurs when the core body temperature drops between 86 - 78°F.	• Severe muscle stiffness; • Very sleepy or unconscious; • Ice cold skin; and • Death.	• Call 911 for an ambulance; • Treat the victim very gently; and • Do not attempt to re-warm. The victim should receive treatment in a hospital.
Frostbite Usually occurs when the skin actually freezes and loses water. Frostbite usually occurs when temperatures are below 30° F. Wind chill factors can allow frostbite to occur in above freezing temperatures.	• Cold, tingling, stinging or aching feeling in the frostbitten area. This is followed by numbness; • Skin color turns red, then purple, then white or very pale. The skin is cold to the touch; and • Blistering in severe cases.	• Call 911 for an ambulance; • Do not rub the area; • Wrap frostbitten area with a soft cloth; • If help is delayed, immerse in warm, not hot, water. Do not pour water on affected area; and • Apply sterile dressings to blisters to prevent breaking.
Trench Foot Usually occurs by having feet immersed in cold water for long periods of time. Similar to frostbite, but less severe.	• Tingling, itching or burning sensation; and • Blisters may also be present.	• Soak feet in warm, not hot, water; • Wrap with a dry soft cloth or bandage; and • Drink a warm, sugary drink.

5.1 Cold Stress Prevention:

5.1.1 Clothing:

- Protective clothing is the most important way to avoid cold stress. The type of fabric also makes a difference. Cotton loses its insulation value when it becomes wet. Wools retains its insulation value even when wet. The following are recommendations for working in cold environments:
  - Wear at least three layers of clothing:
    - An outer layer to break the wind and allow some ventilations (Gortex or nylon);
    - A middle layer of down or wool to absorb sweat and provide insulation even when wet;
    - An inner layer of cotton or synthetic weave to allow for ventilation.
  - Wear a hat. Up to 40% of body heat can be lost when the head is left exposed.
  - Wear insulated boots or other footwear. Tight-fitting footwear restricts blood flow. Footwear should be large enough to allow wearing of either one thick or two thin pairs of socks.
  - Keep a change of dry clothing available in case worn clothes become wet.
  - Regularly inspect cold weather supplies and restock when necessary.
  - Do not wear tight clothing. Loose clothing allows for better ventilation.
  - Cover your mouth to protect your lungs, avoid taking deep breaths, and minimize talking.
  - Employees who get hot while working should open their jackets, but keep hats and gloves on.

5.1.2 Food and Hydration:

- Caffeine is discouraged because it increases the water loss and blood flow to the extremities.
- Employees should drink warm sweet drinks and soups to maintain caloric intake and fluid volume.

5.1.3 Buddy System:

Employees working in cold environments, or who are not acclimated to cold environments should not work alone. In situations, employees should be assigned a “buddy” to provide constant verbal or visual communication. The employees should be aware of symptoms related to cold stress.

5.1.4 Work Schedule:

If possible, heavy work should be scheduled for the warmer parts of the day. Workers should take frequent breaks out of the cold and eat warm, high-calorie food. Try to work in pairs so workers can keep an eye on each other and watch for signs of cold stress. Avoid fatigue since energy is needed to keep muscles warm.

5.1.5 Wind-Chill Index:

Wind-chill index involves the combined effect of air temperature and air movement. Wind-chill cooling rate is defined as heat loss (expressed in watts per meter squared) resulting from the effects of air temperature and wind velocity upon exposed skin. The higher the wind speed and the lower the temperature in the work environment, the great the insulation value of the protective clothing required. The chart below illustrates the wind chill temperature and the levels at which frostbite can occur in 15 minutes or less.

Wind Chill Chart

	Temperature (Fahrenheit)																		
	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Wind (miles per hour)	5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
	10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
	15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
	20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
	25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
	30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
	40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
	45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
	50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
	55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
	60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times **30 minutes** **10 minutes** 5 **minutes**

5.2 Facilities

- Regularly used walkways and travel ways shall be sanded, salted or cleared of snow and ice as soon as practicable.
- Employees will be informed of the dangers associated with working around unstable snow and ice build-ups. All employees will be informed of the dangers and destructive potential caused by unstable snow build-up, sharp icicles, ice dams and know how to prevent incidents caused by them.

- When dangerous overhead build-ups of snow or ice are present barricades will be used to prevent staff from walking or driving into potential fall zones.

5.3 Training:

Training is a critical element of cold stress prevention. All supervisors and employees must receive initial and annual training in 1) the recognition of the signs and symptoms of impending cold illness, 2) the cold stress prevention methods that can reduce the risk of cold illness disorders, and 3) the basic First Aid procedures for cold stress symptoms.

At a minimum, cold stress prevention training will include the following topics:

- Knowledge of the hazards of cold stress;
- TRC's procedures for identifying, evaluating and controlling exposures to the environmental and personal risk factors for cold illness;
- The importance of drinking warm sweet drinks and soups to maintain caloric intake and fluid volume;
- Recognition of predisposing factors, danger signs, and symptoms;
- The importance of immediately reporting symptoms or signs of cold illness in themselves, or in co-workers to the Project Manager or Work Care;
- TRC's procedures for responding to symptoms of possible cold illness, including how emergency medical services will be provided should they become necessary;
- Procedures for contacting emergency medical services, and if necessary, for transporting employees to a point where they can be reached by an emergency medical service provider;
- Awareness of First Aid procedures for, and the potential health effects of, hypothermia;
- The Site Employee(s) responsibilities in avoiding cold stress; and
- Dangers of using antidepressants, sedatives, tranquilizers, and heart medications.

6. REFERENCES/RELATED DOCUMENTATION

CP002 – Risk Analysis/Site-Specific Health and Safety Program

Centers for Disease Control and Prevention, Cold Stress, http://www.cdc.gov/niosh/topics/coldstress

1. PURPOSE

This program outlines the responsibilities and procedures required to support the safe and effective use of radioactive materials and radiation-producing machines used at TRC facilities. The program will provide TRC employees with information and instructions to ensure the safe and proper handling, transportation and control of radioactive equipment; and state how TRC will fulfill its requirements to operate all Portable Nuclear Gauges in conformance with all State and Federal regulations.

2. SCOPE

The regulations and guidelines outlined in this program apply to all persons who actively work with radioactive material as employees of TRC. It is the intent of this program to provide and ensure that all employees involved with radioactive material are aware of the TRC Material License, the obligations of the license, and basic safety practices associated with operating nuclear equipment. This program does not address all situations and field conditions but gives the reader the basic concepts for nuclear safety and operation procedures. Common sense, sound judgment, and adherence to federal regulations should always be exercised by all personnel involved in this area of work.

3. DEFINITIONS

ALARA (As low as is reasonably achievable): Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Background radiation: Radiation from cosmic sources; naturally-occurring radioactive material, including radon (except as a decay product of source or special nuclear material); radiation not under the control of the licensee. *Background radiation* does not include radiation from source, byproduct, or special nuclear materials.

Curie: The measure of the rate at which radioactive atoms decay. The decay rate of one gram of radium is a Curie. Millicurie = one/thousandth of a Curie.

Dose: The quantity of ionizing radiation absorbed, per unit of mass, by the body or by any portion of the body. When the provisions in this section specify a dose during a period of time, the dose is the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use.

Occupational Radiation Dose: The dose of radiation received as a result of working with radioactive materials. It may not exceed 3 rem to the whole body in a calendar quarter or 5 rem to the whole body in a single year.

Rad: A measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit of mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue (1 millirad (mrad) = 0.001 rad).

Radiation: Alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but such term does not include sound or radio waves, or visible light, or infrared or ultraviolet light.

Radiation area: An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radioactive material: Any material which emits, by spontaneous nuclear disintegration, corpuscular or electromagnetic emanations.

Rem: A measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of 1 roentgen (r) of X-rays (1 millirem [mrem] = 0.001 rem). The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions for irradiation.

Restricted area: Any accessible area which is controlled by TRC for purposes of protection of individuals from exposure to radiation or radioactive materials.

Source: Any substance that emits nuclear radiation; usually refers to a quantity of radioactive material conveniently packaged for scientific or industrial use.

Unrestricted area: Any accessible area which is not controlled by TRC for purposes of protection of individuals from exposure to radiation or radioactive materials.

X-ray: Electromagnetic radiation that is similar to gamma except in its origin. X-rays come from the inner orbits of electrons spinning about the nucleus.

4. RESPONSIBILITIES

4.1 The designated Radiation Safety Officer and is responsible for ensuring compliance with radiation safety regulations and the provisions of this program. These responsibilities include the following:

- Ensuring all radioactive material and machines (i.e., X-Ray) are registered with the State in accordance with applicable regulations.
- Ensuring the inventory or radioactive materials and radiation machines are current (see CP014.1).
- Identifying the State radiation safety regulations that apply to the operation. (Refer to Appendix A for a list of State Radiation Agencies for Agreement States.)
- Overseeing operating safety, emergency, and ALARA procedures, and to review them at least annually to ensure that the procedures are current and conform to all State and Federal Regulations.
- Participating in the approval or disapproval for procurement, storage, use, monitoring, disposal, maintaining of necessary records, licenses, and payment of fees.

- Ensuring that required radiation surveys and leak tests are performed and documented in accordance with applicable regulations, including corrective measures when levels of radiation exceed permissible limits.
- Performing leak tests on sealed sources as required.
- Performing special surveys, including wipe tests of sources when received.
- Ensuring that personnel monitoring is used properly by occupationally-exposed personnel, that records are kept of the monitoring results, and that timely notifications are made if required.
- Maintaining documentation of test and survey results.
- Ensuring the proper storing, labeling, transporting, and use of sources of radiation, storage, and/or transport containers.
- Having the responsibility and authority during a suspected or confirmed emergency to take prompt remedial action without prior approval.
- Completing the necessary radiation safety training necessary to implement and maintain the provisions of an effective radiation safety program.

4.2 TRC employees are responsible for the following:

- Understanding and following the radiation safety precautions for specific work areas. This includes procedures for safe use of radioactive materials and correct operating procedures for radiation-producing equipment;
- Participating in radiation safety training as required by this program;
- Participating in radiation exposure monitoring;
- Reporting concerns of unsafe conditions (i.e., potential overexposure to radiation, defective radiation machine, etc.) to the Radiation Safety Officer immediately.

5. PROCEDURE

5.1 Purchase of Radioactive Material:

5.1.1 To maintain an accurate inventory of radioactive sources, the Radiation Safety Officer must be informed prior to the purchases of radioactive material.

5.1.2 These communications will cover sealed sources, unsealed sources, service irradiations, or radiation producing equipment.

5.1.3 Certain radioactive materials and machines must be registered with the State. This typically includes Class 3b and Class 4 lasers and x-ray equipment. The Radiation Safety Officer will evaluate such requests for radioactive materials and obtain the required license and registration authorization prior to receiving the radioactive materials or machines.

5.1.4 The Radiation Safety Officer will retain purchase information to document the historical inventory of radioactive sources and machines.

5.2 Receipt of Radioactive Materials:

5.2.1 All sources shipped to the facility will be directed to the Radiation Safety Officer. The Radiation Safety Officer will receive verification of proper license authorization for the sources. The Radiation Safety Officer will then survey the sources for shipping damage and/or acceptable radiation levels at container surfaces. Storage will be provided as necessary.

5.2.2 If packages bearing radiation labels arrive at the facility, they will be inspected by the Radiation Safety Officer for proper labeling and possible leakage.

5.2.3 Initial removal and handling of sources from shipping containers shall be coordinated by the Radiation Safety Officer. Written evidence of a leak test within a six-month period prior to shipping must be confirmed or a leak test performed, and the results obtained prior to installation. Evidence of a leaking source prior to installation will be referred to the source vendor, and shall be their responsibility.

5.2.4 Prior to the installation of radioactive sources, the Radiation Safety Officer will coordinate an area survey to establish background radiation levels at the source and vessel surfaces. All survey results will be recorded and maintained by the Radiation Safety Officer.

5.3 Transfer of Radioactive Material:

5.3.1 To maintain an accurate inventory of sources, the Radiation Safety Officer must handle all transfer and disposal of radioactive materials and will prepare license and registration amendments when transfers and disposal are planned.

5.3.2 Transfer of radioactive materials must be preceded by exchange of license information and amendments of both parties’ licenses.

5.3.3 Incoming and outgoing shipments will be managed by the Radiation Safety Officer.

5.3.4 The Radiation Safety Officer will package and ship or receive the materials. Transportation offsite must meet Department of Transit (DOT) regulations which include specific rules on packaging, labeling and physical transport.

5.3.5 The Radiation Safety Officer must arrange for all sealed sources to be returned to the manufacturer when they have reached the end of their useful life.

5.3.6 The return of radiation sources to the manufacturer requires that the Radiation Safety Officer be notified and a revised inventory be submitted to the State. Under no circumstances are radioactive materials to be discarded with ordinary wastes. The manufacturer must submit a return letter confirming that they have received the source and have assumed control/responsibility for it.

5.4 Inventory:

5.4.1 The Radiation Safety Officer maintains an inventory of all radioactive materials and machines. (See example in Appendix B.)

5.5 Area Posting and Equipment Labeling:

5.5.1 The Radiation Safety Officer will provide appropriate caution signs for doors and walls of rooms in which radioactive materials are stored or used. Signs can be removed only by the Radiation Safety Officer. Contact the Radiation Safety Officer if caution signs need to be replaced or removed.

5.5.2 The posting of radiation caution signs and labels is required in all areas where radiation equipment or sources are being used or stored. All signs must use the conventional radiation caution colors of magenta or purple on a yellow background and the conventional three-bladed design.

5.5.3 The radiation symbol with appropriate wording must be conspicuously posted in the area where radiation is in use and/or on the radiation device. A typical radiation warning sign for area posting is shown in Figure 17-III. A typical label for devices containing radioactive materials is shown in Figure 17A-III.

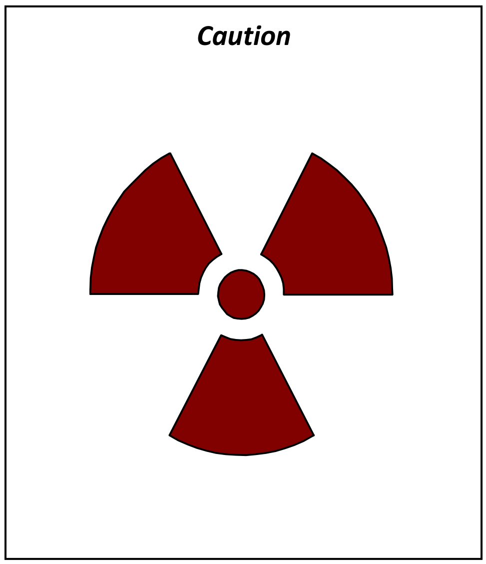


Figure 17-III

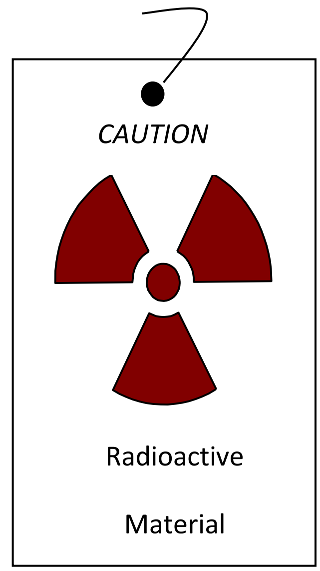


Figure 17A-III

5.5.4 Each radiation area must be conspicuously posted with a sign or signs bearing the radiation caution symbol and reading “Caution Radiation Area”. The specific requirements for area posting and container labeling are covered in Section 20.1902 and 20.1904 of 10 CFR 20 and similar agreement state regulations.

Note: A room or area is not required to be posted with a caution sign because of the presence of a sealed source, provided the radiation level is 12 inches from the surface of the source container or housing, and does not exceed 5 millirems per hour (mrem/hr).

5.5.5 The following information will be posted and/or provided to employees who work in or frequent radiation areas:

- Information regarding location of radioactive materials or areas.
- Safety hazards associated with exposure to such materials or radiation.
- Precautions or devices to minimize exposure.
- Information regarding access to radiation exposure reports.

5.6 Permissible Exposure Limits:

5.6.1 In accordance with 29 CFR 1910.1096, employee exposure levels to ionizing radiation must be limited to the following:

- During any calendar quarter, the dose to the whole body must not exceed 3 rems;

- The dose to the whole body, when added to the accumulated occupational dose to the whole body, must not exceed 5(N-18) rems, where N is the individual's age in years at the last; and
- Any employee who is under 18 years of age to receive in any period of one calendar quarter a dose in excess of 10% of the specified limits in Table 1 below.
- Furthermore, employees allowed to work in a restricted area must not receive in any period of one calendar quarter, a dose in excess of the limits listed in the following Table 1 below.

Table 1
Limits of Exposure to Ionizing Radiation

Area of Exposure	Rems per calendar quarter
Whole body: Head and trunk; active blood-forming organs; lens of eyes; or gonads	1-1/4
Hands and forearms; feet and ankles	18-3/4
Skin of whole body	7-1/2

Source: 29 CFR 1910.1096(b)(1) Table G-18

5.7 Exposure Control Methods:

5.7.1 Time—Decreasing exposure time reduces personnel dose linearly. There is a straight line relationship between total radiation exposure and the time of exposure. Employees should be advised not to stay around radiation sources any longer than necessary. The effect of time on radiation is shown in the Figure below.

100 mR per Hour

1 Hour	**100 mR**
2 Hour	200 mR
4 Hour	400 mR
8 Hour	800 mR

5.7.2 Distance—Increasing the distance between personnel and the radiation source is an effective means of reducing the dose. Notice that this effect follows the inverse square law. That is, at double the distance, the exposure rate is reduced to one-fourth, at three times the distance, the exposure rate is reduced to one-ninth, and at four times the distance, the exposure rate is reduced to one-sixteenth. It is possible to reduce radiation exposure considerably by moving farther from the source of radiation. The effect of distance on radiation exposure is shown in the figure below.

1 Foot	100 mR
2 Feet	1/4 * 100 = 25 mR
3 Feet	1/9 * 100 = 11 mR
4 Feet	1/16 * 100 = 6.25 mR
5 Feet	1/25 * 100 = 4 mR
6 Feet	1/36 * 100 = 2.8 mR
7 Feet	1/49 * 100 = 2 mR
8 Feet	1/64 * 100 = 1.5 mR
9 Feet	1/81 * 100 = 1.2 mR
10 Feet	1/100 * 100 = 1 mR

5.7.3 Shielding—Shielding a source of radiation generally reduces the radiation levels around the radioactive source. The effect of shielding is shown in the figure below. For this illustration, a shielding thickness of one-half value layer was chosen. This means that this particular thickness will reduce the intensity of radiation by one-half. The half-value layer is different for different sources. Higher energy radiation requires larger half value layers than low energy radiation. See shielding example below:

Unshielded Source	100 mR/Hr
1 half-value layer	50 mR/Hr
2 half-value layer	25 mR/Hr
3 half-value layer	12.5 mR/Hr

6. SAFE OPERATING PROCEDURES

6.1 Sufficient shielding must be installed for radiation machines to ensure radiation levels in employees' work areas are ALARA.

6.2 Suitable barriers, warning devices and interlocking systems must be used as required to prevent unauthorized personnel from gaining access to high radiation areas in the vicinity of radiation machinery. Devices to be utilized may include:

- Dead-man foot switch at the operator station.
- Heavy duty radiation switch on the door to the x-ray room.
- Visual/audible alarm inside the x-ray room.
- Emergency stop switch inside the x-ray room.

- Alarm outside the x-ray room prior to x-ray production.

6.3 Workers involved in the operation and maintenance of x-ray units must be trained in the hazards of x-rays.

6.4 Workers involved in the operation of x-ray units must wear a personal monitoring device that is changed on a monthly basis.

6.5 Workers must be provided a copy of their exposure results at least annually.

6.6 Any disassembly, reassembly, maintenance, or when personnel exposures appear abnormal, requires Radiation Safety Officer's inspection and radiation survey.

6.7 TRC employees are strictly prohibited from making adjustments to radiation-producing machines. Shielding should be verified prior to each use. Maintenance on radiation-producing machines must be performed by the equipment manufacturer's authorized representative.

6.8 Using the exposure control methods described in Section 5.7, the sites will prepare written radiation safety operating procedures for all registered radiation source materials and machines. Standard Operating Procedures (SOPs) will specify both the routine and emergency procedures to be followed.

GUIDANCE NOTE: Radiation Safety Procedures may be included in the operating manual that accompanies a radiation unit. If safety procedures are not included in the manual, they must be developed. These safety procedures must be posted on the machine or where the operator can observe them while using the machine.

6.9 Personal Dosimetry:

6.9.1 In addition to the area survey, it is recommended that a film badge survey be included. To accomplish this, suitable badges supplied by the Radiation Safety Officer are posted at several locations near a radiation installation. The survey should run from 1 to 4 weeks to obtain a good measure of the long-term radiation conditions. Surveys conducted with instruments can miss small leaks, and there is potential for radiation pattern changes with equipment operation.

6.9.2 Film badges will be worn by employees working in a designated Radiation Area.

6.9.3 Film badges may be required if employees are potentially exposed to 50% (25% for people under 18 and pregnant women) of the permissible dose. Wear film badges as specified by the Radiation Safety Officer whenever exposure to radiation may occur.

6.9.4 When film badges are not in use, badges will be stored such that they receive minimal radiation exposure.

6.9.5 Laboratory area surveys must be conducted at scheduled intervals. The surveys must consist of area radiation measurements as well as wipe tests conducted primarily in areas where sources have been used or stored. Complete records of all surveys must be maintained.

6.9.6 A very thorough radiation survey must be conducted when a new installation is being placed in service. It is preferable to conduct the survey as early as possible to avoid start-up delays if the installation needs modifications. Radiation surveys must be repeated whenever the installation is changed in any way that might affect the radiation pattern or the shielding.

6.9.7 Periodic routine checks are recommended. These need not be full-scale surveys; a spot check at a few points of interest is sufficient. At the very minimum, a visual inspection must be made for all radiation equipment whenever leak tests are being conducted. Results should be recorded and maintained.

6.10 Leak Tests:

6.10.1 The wipe testing may be contracted out or performed by the Radiation Safety Officer. The field test is conducted by wiping the device in which the source is installed with a small cotton swab. The wipe is then transferred to a vial while being careful not to touch it with bare hands. The vial is marked to identify the source wiped. The wipes are then checked with an extremely sensitive counting device, and a final report is issued stating the results and the measurement sensitivity.

6.10.2 Sealed sources must be leak tested every six months when in use or as required. A record of the test results must be maintained.

6.10.3 Sealed beta and/or gamma sources (except for gases) containing material other than tritium, with half-life greater than 30 days, will be tested for leakage prior to initial use and every 6 months thereafter. These sources need not be leak tested if they are in storage, but must be tested when removed from storage before use or transfer.

Exception: Sealed sources containing 100 µCi or less of beta and/or gamma-emitting material or 10 µCi or less of alpha-emitting material are exempt from the leak test requirements.

6.10.4 Leak tests will be performed by the Radiation Safety Officer and records of the test results will be maintained. Leaking sealed sources cannot be used; they will be taken out of service.

6.10.5 Sealed source installation must be designed to operate within the radiation levels specified for unrestricted areas. The Nuclear Regulatory Commission (NRC) considers an unrestricted area to be an area where access or entry is not restricted or controlled. In unrestricted areas, federal and state laws require that the radiation level in work areas be less than 2 mrem/hr on a continuous basis or less than 100 mrem/week on an intermittent basis. In any case, non-radiation workers must not be allowed to receive more than 100 mrem in a calendar year.

6.10.6 If a leak test shows 0.005 microcuries or more of removable contamination, the source must be removed from service. However, any source that shows any detectable contamination should be removed from service, repaired, and decontaminated before being used again in a laboratory or field service.

6.11 Pregnant Workers:

6.11.1 Workers who have declared their pregnancy will be issued an extra dosimeter for fetal monitoring.

6.11.2 Under some state provisions, pregnant workers may request reassignment if their appropriate health care provider deems it necessary.

6.12 Calibration:

6.12.1 All radiation monitoring equipment must be calibrated periodically on a schedule established by the Radiation Safety Officer. The calibration records must be maintained for all monitoring equipment in the laboratory. Methods of conducting personnel and area monitoring are listed in Appendix C.

7. EMPLOYEE TRAINING

7.1 TRC employees will receive proper radiation safety training, which is at least commensurate with the degree of potential hazards to be encountered. Appendix D contains radiation safety information which can be used for awareness training.

7.2 All associates who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) will be trained on the following:

- The storage, transfer or use of sources of radiation (i.e., where sources are located).
- The health risks associated with exposure to sources of radiation, the precautions to minimize radiation exposure, and the purposes and functions of protective devices employed.
- The key regulations.
- Operating and emergency procedures applicable to radiation sources.
- Their responsibility to any unsafe condition.

- The right to receive radiation exposure reports.

7.3 To qualify for work with radioactive materials, laboratory personnel must have training in the following areas:

- The Nature of Radiation.
- The Detection of Radiation.
- Radiation Units.
- Permissible Exposure Levels.
- Biological Effects of Radiation.
- Monitoring Techniques.
- Emergency Procedures.

8. EMERGENCY SITUATIONS

8.1 The Radiation Safety Officer must be notified of known or suspect radiation exposures that could exceed the permissible exposure limit; if exposure by inhalation, ingestion, or injection has occurred; or if radiation machines have been damaged.

8.2 The first step following an accident involving radioactive source material or machine is to notify the designated occupational medical staff (internal or external). The Radiation Safety Officer will determine if the State or Federal Agency must be notified. In determining the extent of damage to the radiation installation, the following steps are necessary:

8.2.1 If necessary, find the source holder by surveying with an appropriate meter.

8.2.2 Inspect the source holder and shutter for physical damage (from a safe distance).

8.2.3 Close the shutter, if possible and safe to do so.

8.2.4 Rope off the area around the source to prevent personnel overexposure. The rope should represent the 2 mrem/hr isodose line.

8.2.5 If area contamination is suspected, the general area should be isolated and personnel should be monitored before leaving the area. Equipment and vehicles leaving the area should also be checked. If it is suspected that injured personnel may be contaminated, the local hospital will be advised so that appropriate action can be taken.

8.2.6 The Assistant Secretary of Labor or the Assistant's duly authorized representative will be notified immediately by telephone of any incident involving radiation that may have caused or threatens to cause any of the following:

- The exposure of the whole body of any individual to 25 rems or more of radiation;
- The exposure of the skin of the whole body of any individual to 150 rems or more of radiation;
- The exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation; or
- The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limit specified for such materials in 10 CFR 20, Appendix B, Table 2.

8.3 The Assistant Secretary of Labor or the Assistant's duly authorized representative will be notified within 24 hours by telephone of any incident involving radiation that may have caused or threatens to cause any of the following:

8.3.1 The exposure of the whole body of any individual to 5 rems or more of radiation;

8.3.2 The exposure of the skin of the whole body of any individual to 30 rems or more of radiation;

8.3.3 The exposure of the feet, ankles, hands, or forearms of any individual to 75 rems or more of radiation.

9. RECORDKEEPING

9.1 Records associated with this program will be maintained by the Radiation Safety Officer as indicated by federal and state requirements.

Record	Period of Time
License applications, evaluations, and authorizations.	3 years
Radiation Safety Training certificates for radiation workers	3 years
Area Monitoring	2 years
Inventory of Radiation Material and Machines	2 years (after material has been removed from site)
Instrument Calibration Records	4 years
Employee exposure monitoring Records	30 years (after last date of employment)

10. FEDERAL AND STATE REGULATIONS

10.1 Federal Regulations:

10.1.1 Employers regulated by the NRC are governed by 10 CFR 20 standards. Employers in an NRC-agreement state (such states are listed in 29 CFR 1910.1096[p][3]) are governed by the requirements of the laws and regulations of that state.

10.1.2 The regulations developed by the Nuclear Regulatory Commission are presented in The Code of Federal Regulations. The code is identified as CFR, Title 10 - Energy. A copy of Title 10 is available from the Supt. of Documents, US Gov. Printing Office, Washington, DC 20402. At the present time, they are the basis of federal control over radiation in several states.

10.1.3 The only states not having federal control over radioisotopes are those having agreements providing for state control. In these Agreement States (see Appendix A), the state regulations on radiation control are compatible with the NRC regulations.

10.2 DOT Regulations:

10.2.1 The DOT has developed the following regulations governing interstate transportation of radioactive materials. The code is identified as CFR, Title 49 - Hazardous Materials Regulations:

- CFR, Title 49 - Part 173 Regulations Applying to Shippers.
- CFR, Title 49 - Part 177 Regulations Applying to Shipments made by way of Common, Contract, or Carriers by Public Highway.
- CFR, Title 49 - Part 178 Shipping Container Regulations.

10.3 State Regulations:

10.3.1 State radiation safety regulations can vary significantly; therefore, each TRC facility should identify the specific State regulations applicable to their operation. Appendix B contains an example inventory of State radiation safety regulations.

10.3.2 The facility Radiation Safety Officer should identify which Federal and State regulations apply to the facility.

11. REFERENCES/RELATED DOCUMENTATION

Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.)

10 CFR 20 Appendix B Table 2 – Annual Intake Limits

10 CFR 20.1904 – Labeling Requirements

10 CFR 20.1902 – Posting Requirements

29 CFR 1910.1096 – Ionizing Radiation Standard

Appendix A –Agreement States Directory

Appendix B – Register of Legal Requirements

Appendix C – The Detection of Radiation

Appendix D – Radiation Safety Information

Appendix E – Example Annual Radioactive Audit

CP014.1 – Inventory of Radioactive Materials and Devices Sample Tracking Form

APPENDIX A

AGREEMENT STATES DIRECTORY

APPENDIX A

AGREEMENT STATES DIRECTORY

Any employer who possesses or uses source material, or uses radiation sources other than source material, byproduct material, or special nuclear material, as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), and has either registered such sources with, or is operating under a license issued by, a State which has an agreement in effect with the Nuclear Regulatory Commission pursuant to section 274(b) (42 U.S.C. 2021[b]) of the Atomic Energy Act of 1954, as amended, and in accordance with the requirements of that State's laws and regulations shall be deemed to be in compliance with the radiation requirements of this section, insofar as his possession and use of such material is concerned, unless the Secretary of Labor, after conference with the Nuclear Regulatory Commission, shall determine that the State's program for control of these radiation sources is incompatible with the requirements of 29 CFR 1910.1096.

An Agreement State is one that has signed an agreement with the Nuclear Regulatory Commission under which the state regulates the use of by-product, source and small quantities of special nuclear material within that state. At the time of this program revision, the following are Agreement States as listed in 29 CFR 1910.1096(p)(3)(i):

State	Radiation Safety Agency
Alabama	Division of Radiation Control State Department of Public Health State Office Building 572 East Patton Avenue Montgomery, AL 36130-1701 (205) 242-5315
Arizona	Arizona Radiation Regulatory Agency 4814 South 40th Street Phoenix, AZ 85040 (602) 255-4845
Arkansas	Division of Radiation Control and Emergency Management Department of Health 4815 West Markham Street, Slot 30 Little Rock, AR 72205-3876 (501) 661-2301

State	Radiation Safety Agency
California	Radiologic Health Branch Environmental Health Division State Department of Health Services 714/744 P Street P.O. Box 942732 Sacramento, CA 94234-7320 (916) 322-3482
Colorado	Radiation Control Division (RCD-DO, B1) Colorado Department of Health 4300 Cherry Creek Drive South Denver, CO 80222-1530 (303) 692-3030
Florida	Office of Radiation Control Department of Health and Rehabilitative Services 1317 Winewood Boulevard Tallahassee, FL 32399-0700 (904) 487-1004
Georgia	Radioactive Materials Program Department of Natural Resources 4244 International Parkway, Suite 114 Atlanta, GA 30354 (404) 362-2675
Kansas	X-Ray and Radioactive Materials Control Section Department of Health and Environment Bureau of Air and Radiation 109 S.W. 9th Street Topeka, KS 66612 (913) 296-1562
Kentucky	Radiation Control Branch Cabinet for Human Resources 275 East Main Street Frankfort, KY 40621-1000 (502) 564-3700

State	Radiation Safety Agency
Louisiana	Radiation Protection Division Office of Air Quality and Radiation Protection 7290 Bluebonnet Road P.O. Box 82135 Baton Rouge, LA 70884-2135 (504) 765-0112
Maryland	Radiological Health Program Air and Radiation Management Administration Department of the Environment 2500 Broening Highway Baltimore, MD 21224 (410) 631-3300
Mississippi	Division of Radiological Health State Department of Health 3150 Lawson Street P.O. Box 1700 Jackson, MS 39215-1700 (601) 354-6657
Nebraska	Division of Radiological Health Department of Health 301 Centennial Mall South P.O. Box 95007 Lincoln, NE 68509 (402) 471-2168
New Hampshire	Radiological Health Bureau Division of Public Health Services Health and Welfare Building 6 Hazen Drive Concord, NH 03301-6527 (603) 271-4588
New York	Division of Policy Analysis and Planning 2 Rockefeller Plaza Albany, NY 12223 (518) 473-0048

State	Radiation Safety Agency
North Carolina	Division of Radiation Protection Department of Environment, Health and Natural Resources 3825 Barrett Drive P.O. Box 27687 Raleigh, NC 27611-7687 (919) 571-4141
North Dakota	Division of Environmental Engineering Department of Health 1200 Missouri Avenue, Room 304 P.O. Box 5520 Bismarck, ND 58502-5520 (701) 221-5188
Oregon	Radiation Control Section State Health Division Department of Human Resources 800 N. E. Oregon Street #21 P.O. Box 14450 Portland, OR 97214-0450 (503) 731-4014
South Carolina	Bureau of Radiological Health Department of Health and Environmental Control 2600 Bull Street Columbia, SC 29201 (803) 734-4700
Tennessee	Division of Radiological Health L and C Annex, Third Floor 401 Church Street Nashville, TN 37243-1532 (615) 532-0364
Texas	Bureau of Radiation Control Texas Department of Health 1100 West 49th Street Austin, TX 78756-3189 (512) 834-6688

State	Radiation Safety Agency
Washington	Division of Radiation Protection Department of Health, LE-13 Airdustrial Center Building #5 P.O. Box 47827 Olympia, WA 98504-7827 (206) 586-8949

APPENDIX B

REGISTER OF LEGAL REQUIREMENTS – STATE OF TENNESSEE EXAMPLE

APPENDIX B

REGISTER OF LEGAL REQUIREMENTS – STATE OF TENNESSEE EXAMPLE

Regulatory Topic	Requirements	State Regulation
License and Registration	Unless exempt, a specific or general license must be issued to any person who possesses, uses, transfers, owns, or acquires radioactive material.	1200-02-10-.09
	An annual registration fee must be submitted by the first working day following January 1st of each year.	1200-02-10-.24
	Radiation devices can only be transferred in accordance with all requirements listed in State rule 1200-02-10, which includes notification to the State.	1200-02-10
Training	Individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) must be trained on the topics listed in TN Rule 1200-02-04-.12, which includes the location of radiation sources, health effects of radiation, and the precautions required to minimize exposure to radiation.	1200-02-04-.12
Radiation Safety Program	Periodically (at least annually) review the radiation protection program content and implementation, and keep records of the review for 3 years.	1200-02-05-.40; 1200-02-05-.131
Radiation Dose Exposure	Limit the occupational dose to individual adults to the following annual dose limits: An annual limit that is the lesser of: ▪ A total effective dose equivalent of 5 rems (0.05 Sv) or ▪ The sum of the deep–dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye equal to 50 rems (0.5 Sv).	1200-02-05-.50
	The annual limits to the lens of the eye, to the skin of the whole body and to the skin of the extremities are: ▪ A lens–dose equivalent to 15 rems (0.15 Sv), and ▪ A shallow–dose equivalent of 50 rems (0.50 Sv) to the skin of the whole body or to the skin of any extremity.	1200-02-05-.50

Regulatory Topic	Requirements	State Regulation
	The licensee shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person (i.e., previous employer).	1200-02-05-.50
	The annual occupational dose limits for minors (less than 18 years of age) are 10 percent of the annual dose limits specified for adults.	1200-02-05-.50
	Dose equivalent to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, must not exceed 0.5 rem (5 mSv).	1200-02-05-.56
General Survey & Monitoring Requirements	Radiation surveys shall be made as necessary to ensure compliance with State regulations. Instruments used to perform radiation surveys shall be calibrated as necessary.	1200-02-05-.70
Individual Monitoring	Each licensee and registrant shall monitor occupational exposure to, and shall supply and require the use of individual monitoring devices by: 1. Adults likely to receive, in one (1) year from sources external to the body, a dose in excess of 10 percent of the limits in 1200-02-05-.50; 2. Minors likely to receive, in one (1) year from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv), a lens dose equivalent in excess of 0.15 rem (1.5 mSv), or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem (5 mSv); 3. Declared pregnant women likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv) 2; and 4. Individuals entering a high[1] or very high radiation area.	1200-02-05-.71
	Records of individual exposure monitoring must contain the requirements listed in 1200-02-05-.135, and must be recorded on the TN form RHS 8-2C or equivalent form.	1200-02-05-.135.

Regulatory Topic	Requirements	State Regulation
Posting	Each radiation area (where radiation levels exist which could expose a major portion of the body to a dose in excess of 5 millirems in one hour and/or 150 millirems in five consecutive days) shall be conspicuously posted with a sign stating "CAUTION RADIATION AREA". A room or area containing a sealed device is not required to be posted with a caution sign, provided the radiation level at 30 centimeters from the surface of the source container or housing does not exceed 0.005 rem (0.05 mSv) per hour.	1200-02-05-.111
	Current copies of the following documents, or a notice which contains the location of these documents, must be posted: ▪ "State Regulations for Protection Against Radiation;" ▪ Radioactive material license and amendments; ▪ Certified registration and amendments; ▪ Form RHS 8-3 (Notice to Associates) – required to be posted when employees are working in or frequenting any portion of a restricted area.	1200-02-04-.11
Device Labeling	Assure that all labels affixed to the device at the time of receipt and bearing the statement that removal of the label is prohibited, are maintained.	1200-02-10-.09
Inspection	Inspections of radiation machines are to be conducted by the Tennessee Department of environment and Conservation (TDEC) or persons (s) who are registered with the TDEC's Division of Radiological Health.	1200-02-10-.27
Leak Test	Persons who possess radioactive material in a device pursuant to the general license shall assure that the device is tested for leakage of radioactive material and proper operation of the on-off mechanism and indicator, if any, at no longer than six-month intervals or at such other intervals as are specified in the label. **Note: Devices containing only krypton need not be tested for leakage of radioactive material.**	1200-02-10-.09
Notification of Incidents	The Tennessee Division of Radiological Health must be notified as soon as possible (in some cases within 4 hours), if incidents and exposures involving radiation occur.	1200-02-05-.141 - 145

Regulatory Topic	Requirements	State Regulation
Recordkeeping	The licensee shall retain each record of receipt of radioactive material as long as the material is possessed and for three years following transfer or disposal of the material.	1200-02-10-.26
	The licensee who transferred the material shall retain each record of transfer for three years after each transfer.	1200-02-10-.26
	The licensee shall retain records of leak tests and the operation of the on-off mechanism and indicator for 3 years.	1200-02-10-.26

APPENDIX C

THE DETECTION OF RADIATION

APPENDIX C

THE DETECTION OF RADIATION

Film Badges

The film badge, worn on the outer clothing, is the most common personnel radiation monitor. Radiation interacts with the silver atoms in a photographic film to affect the film the same as electromagnetic light rays do. It then is a simple matter to measure the amount of darkening of a film, compare it to a control film that was not exposed to radiation, and determine the amount of radiation exposure. The film badge holder has open window areas and filter areas that allow the type and quantity of radiation to be determined. The following film badge precautions should be observed:

- Store film supplies in a cool dry place to avoid premature fogging of the film. Monitoring film, like all other photographic film, deteriorates with age, heat and humidity.
- Handle film badges carefully to avoid physical damage. If it is absolutely necessary to write on films, do not press too hard with the pen or pencil.
- When sending badges in to be developed and read, do not use paper clips or tape on the badges.
- When wearing the badge, be sure the number is visible in the open window. The number imprinted on the badge should be up and facing outward from the wearer's body.

Pocket Dosimeters

The pocket dosimeter is a direct reading portable unit that looks like a pencil. It is generally used to measure X and gamma radiation but some units are also available for neutron monitoring. They are generally worn in pairs to minimize the possibility of false readings. The instrument consists basically of a quartz fiber, a scale, a lens to observe the movement of the fiber across the scale, and an ionization chamber. The fiber is charged until it reaches zero on the scale. Then as it is exposed to radiation, some of the air atoms in the chamber become ionized. This allows charge to leak from the quartz fiber in direct relationship to the amount of radiation present. As the charge leaks from the fiber, it deflects to some new position on the scale indicating the amount of radiation exposure. Since the pocket dosimeter is a somewhat delicate device which can be accidentally discharged if dropped or used in high humidity areas, its use should be limited to monitoring jobs where meaningful readings can be obtained. Of course, the main advantage of the pocket dosimeter is that it allows the individual to read his radiation dose while he is working with radiation rather than waiting a week or more for a film badge report. Generally, pocket dosimeters are used in laboratory work where the radiation problem is not always easy to evaluate. For use in industrial radiation installation work, the pocket dosimeter must be applied with caution.

Ionization Chambers

Ionization chambers contain two electrodes with a suitable DC voltage applied. Then as radiation creates ion pairs in the chamber, the ions are collected and an ion current flows in an external circuit producing a voltage across a suitable resistor. However, because the currents are extremely small, very large resistors must be used in order to develop a usable voltage. Even then this voltage must be amplified in order to operate meters and other indicating devices. The high resistance circuits are difficult to maintain and the DC amplifiers tend to drift. As a result, when instruments of this type are suitably compensated to minimize these problems, the circuits become rather complicated. However, since the ionization chamber measures ionization directly and is energy independent, it is a very useful and popular tool for both radiation safety and gauging work.

Proportional Counters

Proportional counter construction is similar to the ionization chamber, but they are operated differently. The two electrodes in the proportional counter are operated at a higher DC voltage than the ionization chamber. In this way, the ions that have been formed in the chamber are not merely collected. The higher electrode voltages actually attract the ions with a stronger force causing them to move toward the electrodes much faster. Then when the ions get near the electrodes, they are moving fast enough to cause other gas atoms to ionize. This additional or secondary ionization progresses until an avalanche or breakdown of the gas atoms occurs at the electrodes. This action results in a voltage pulse whose size is proportional to the energy of the radiation. This accounts for the name of this detector.

Geiger-Mueller Counters

The Geiger counter, as it is commonly called, has a detection element constructed similarly to the ion chamber and proportional counter. That is, it is a gas-filled chamber containing two electrodes. The other stainless steel cylinder is one electrode and the central wire is the other electrode. The two electrodes are insulated from each other by special glass to metal seals at each end of the cylinder. This construction provides an extremely rugged detector where rough usage is expected. The Geiger counter generally contains a highly pressurized special gas and the electrodes are operated at a higher voltage than ion chambers or proportional chambers. The incoming radiation begins ionizing the gas and the ions produced are accelerated so rapidly by the higher potential between the electrodes that secondary ionization occurs, resulting in a very large avalanche effect filling the tube volume with ion pairs. One disadvantage is that all output pulses are of the same magnitude no matter how much energy the incoming radiation has. In a thin wall, Geiger tube, alpha, beta and gamma radiation will produce essentially the same size output pulse. Geiger tubes are used with special shields to distinguish between the types of radiation. They are also available because the tremendous avalanche effect makes them sensitive and very small dose rates can be measured.

Scintillation Counters

The family of detectors known as scintillation instruments employs a different means of detecting radiation than the detectors previously mentioned. The word “scintillate” means to emit flashes of light. A scintillating crystal or any other scintillating material, emits tiny flashes of light after being excited to a higher energy level by absorbing the entering radiation. These light flashes are collected by a light sensitive tube known as a photomultiplier tube. This tube converts the light flashes into pulses of electrons which are amplified and collected at a readout point. Scintillators are high efficiency counters for two reasons. First, the output pulses of the scintillator last for a very short duration so that pulses can be counted at a considerably higher rate than with other detectors. Secondly, crystal scintillators will absorb or interact with more incoming radiation than air- or gas-filled tubes because scintillators are much denser (more atoms per volume in the detector).

Instrument Calibration

Radiation measuring instruments like other electronic devices depend on accuracy of reading to be useful. Thus, a calibration check is a necessary part of the general maintenance program. Calibration checks require a source of radiation of known intensity. A low strength source for operational check purposes is attached to the side of those instruments used in plant radiation safety program. For detailed calibration procedures, the instrument’s instruction manual must be consulted. Instruments should be returned to the designated location for any repair or recalibration required.

APPENDIX D

RADIATION SAFETY INFORMATION

APPENDIX D

RADIATION SAFETY INFORMATION

X-rays vs. Gamma Rays

From the foregoing discussions, we can see that X-rays and gamma rays appear to be similar since they occupy a common range in the electromagnetic spectrum. The two difference names are used merely to indicate the origin of the radiation. For example, X-radiation is produced in the orbiting electron portion of the atom (see Figure 2-IIIA) while gamma radiation is produced in the nucleus (see Figure 2-IIIB). Historically, X-rays were discovered first, and generally are machine produced while gamma rays were discovered more recently, and are spontaneously emitted from radioactive materials.

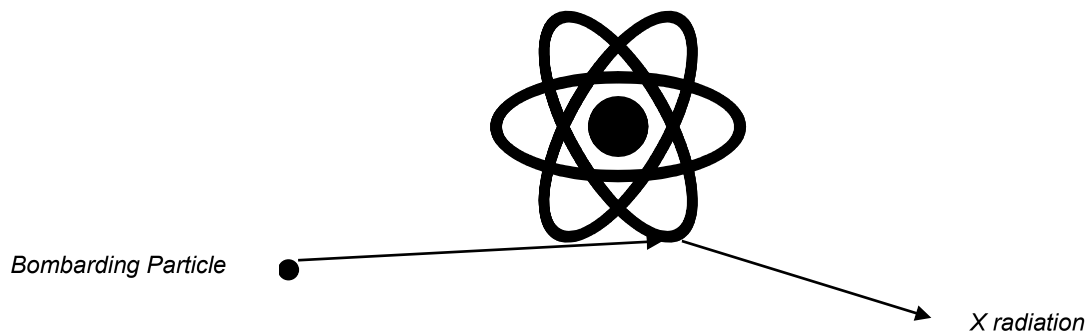


Figure 2-IIIA

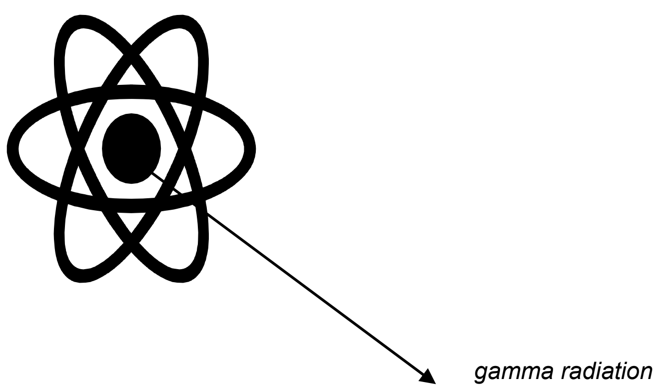


Figure 2-IIIB

Nuclear Radiation

The term nuclear radiation describes all forms of radiation energy that originate in the nucleus of a radioactive atom. In addition to the gamma rays or electromagnetic waves just described, fast moving particles may also be emitted from radioactive atoms. But before we discuss these particles, let's first see how atoms become radioactive. Some materials are naturally radioactive but the process of making a material radioactive might be compared to heating an object in an oven to some temperature above normal. Upon removal from the oven, the object is in an excited state and radiates energy in the form of heat until it returns to a stable state at room temperature. Similarly, radioactive atoms may be produced by "heating" stable, non-radioactive atoms in a "nuclear furnace". The "nuclear furnace" is a reactor or accelerator, and the "heat" is actually in the form of nuclear particles such as neutrons. Some of the non-radioactive atoms are converted to radioactive atoms when an extra neutron is captured by a nucleus. This process is illustrated in Figure 3-III. The radioactive atom is unstable because of the extra energy and the extra particle added to the nucleus. The excited or radioactive atoms get rid of their excess energy and return to a stable state by radiating gamma rays (electromagnetic waves) or nuclear particles from the nucleus. The most important particles are alpha particles (a), beta particles (B), and neutrons (n).

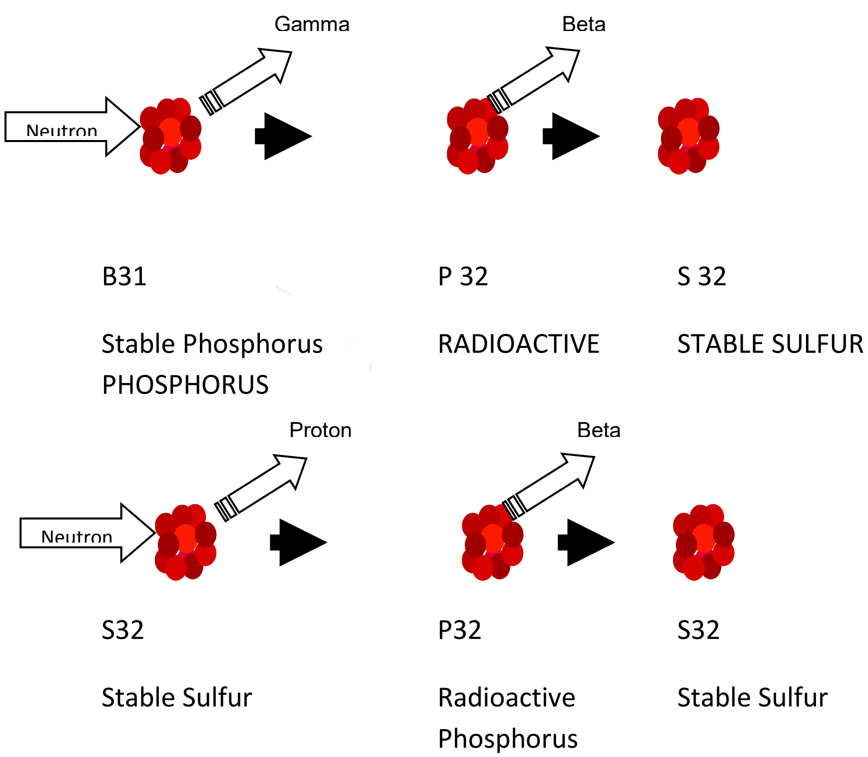


Figure 3-III

Alpha Particles

An alpha particle is comparatively heavy and positively charged. It is usually emitted from the radioactive nuclei of heavy elements such as uranium, thorium, and radium. Alphas can travel only about an inch in air and are easily stopped by a thin sheet of paper or the outer layers of the skin.

Beta Particles

A beta particle is a high speed electron. It is much lighter than an alpha and it is negatively charged. Beta particles are emitted by radioactive materials such as carbon 14 or strontium 90. They can travel a maximum of a few feet in air and can penetrate to 1/3 of an inch of body tissue. They can be easily stopped by a thin sheet of aluminum or an inch of wood.

Neutrons

Neutrons are electrically neutral particles which weigh about one-fourth as much as an alpha particle. They can travel long distances through the air and are highly penetrating. They can be stopped by several feet of water or special concrete. Generally, conventional shielding material such as lead and iron are not effective for neutron shielding. Special precautions are required.

Figure 4-III illustrates the relative shielding required to stop the most common types of nuclear radiation.

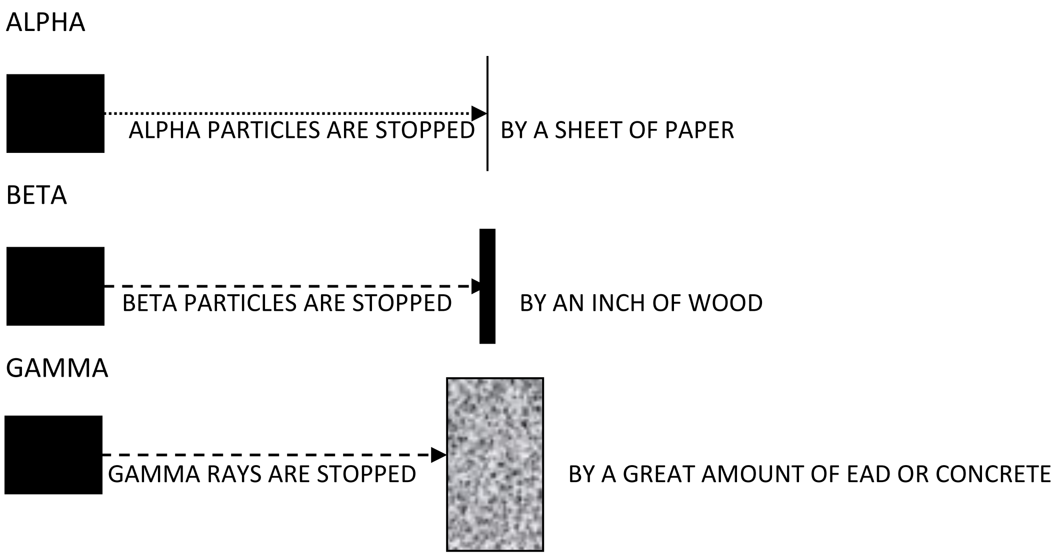


Figure 4-III — Shielding Against Nuclear Radiation

Biological Effects of Radiation

Radiation and the Body

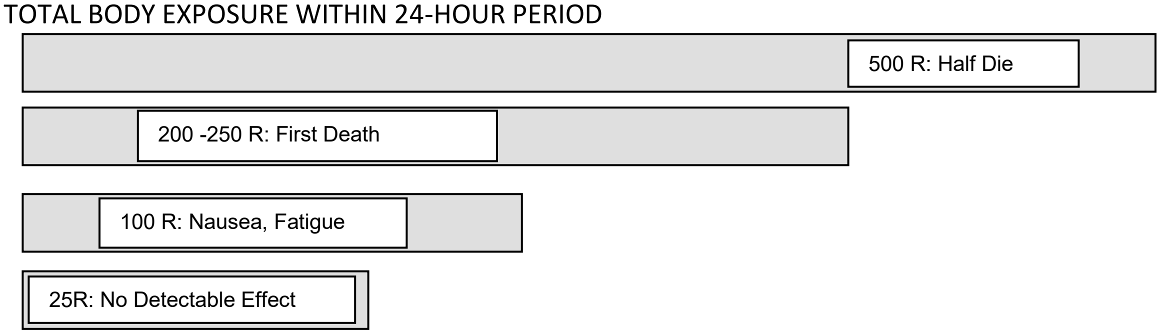
Radiation interacts with the atoms in the body in the same way that it does with all other matter. That is, by ionization. Furthermore, it is clear that when an atom has been ionized (lost an electron), it is changed and will not act like a normal atom. It should be remembered that the human body is a complex chemical machine which is constantly producing new cells to replace those that have died or been damaged. In fact, the body has a tremendous capability for repairing cell damage. Therefore, in order to survive, one must keep cell damage within the body's repair capabilities. Perhaps one of the most common examples of radiation damage is sunburn. Sunlight is electromagnetic radiation similar to X-rays and gamma rays. But since the infrared and ultraviolet rays in sunlight are relatively low energy radiations, they do not penetrate very deeply and damage is limited to the outer layers of skin. As the damaged skin cells die, the red turns to tan and eventually the outer layers peel off. Overexposures have been known to result in first degree burns and even death. This is an example of severe body damage beyond the repair capability. The more energetic electromagnetic radiations (X-rays and gamma rays) can penetrate deeper into the body, or even pass completely through, ionizing the atoms of certain cells in their path. This spreads the damage over a much larger volume, avoiding the localized surface damage observed with lower energy radiation. The real problem with the more penetrating radiation results from their ability to damage cells of the blood forming, and reproductive organs.

Radiation Damage

Now that we know how radiation damages tissue and about the establishment of safe radiation levels, let's examine a chart of effects. Figure 16-III shows the effects of various amounts of radiation administered over a relatively short period of time. It should be noted that there is a very large safety factor between the allowable radiation dose and the point where serious physical damage occurs. Another safety factor is present that is not quite so obvious. This is the time effect. For example, a person can accumulate a good looking suntan over the summer, but he would probably be in serious trouble if he tried to get the same exposure in a single day. It is, therefore, best to spread a given exposure out over a long period of time to give the body time to make necessary repairs. Even through there are very substantial safety factors between the allowable radiation and physical damage, radiation exposures should be minimized as much as possible. This is in line with the minimum possible exposure theory and all good common sense safety theory that says, "DON'T EXPOSE YOURSELF TO ANY HAZARD UNNECESSARILY."

Figure 16-III – Biological Effects of External Radiation

TOTAL BODY EXPOSURE WITHIN 24-HOUR PERIOD



NOTE: The allowable yearly dose by NRC Standards is 5 REM.

APPENDIX E

EXAMPLE ANNUAL RADIOACTIVE AUDIT

APPENDIX E

EXAMPLE ANNUAL RADIOACTIVE AUDIT

(NOTE: All areas indicated in audit notes may not be applicable to every license and may not need to be addressed during each audit.)

Licensee's Name:__xxxxxxx ___________NRC License No.__xx-xxxxx-xx_________

PA DEP License No.__PA-xxx_________

NY DOH License No._DH xx-xxxx

NJ DEP License No._RADxxxxx-xxxxxx

Auditor: _________________ Date of Audit ________ Telephone:_________________

No.___16____________________

____
(Signature)

1. **AUDIT HISTORY**
    a. Last audit of this location conducted on (date).
    b. Were previous audits conducted yearly? *[10 CFR 20.1101]*
    c. Were records of previous audits maintained? *[10 CFR 20.2102]*
    d. Were any deficiencies identified during last two audits or two years, whichever is longer?
    e. Were corrective actions taken? (Look for repeated deficiencies.)

2. **ORGANIZATION AND SCOPE OF PROGRAM**
    a. If the mailing address or places of use changed, was the license amended?
    b. If ownership changed or bankruptcy filed, was *NRC* prior consent obtained or was *NRC* notified?
    c. If the *RSO* was changed, was license amended? Does new RSO meet *NRC* training requirements?
    d. If the designated contact person for *NRC* changed, was *NRC* notified?
    e. Does the license authorize all of the *NRC*-regulated radionuclides contained in gauges possessed?
    f. Are the gauges as described in the Sealed Source and Device *(SSD)* Registration Certificate or Sheet? Have copies of (or access to) *SSD* Certificates? Have manufacturers' manuals for operation and maintenance? *[10 CFR 32.210]*
    g. Are the actual uses of gauges consistent with the authorized uses listed on the license?

h. Is *RSO* fulfilling his/her duties?

3. TRAINING AND INSTRUCTIONS TO WORKERS

a. Were all workers who are likely to exceed 100 mrem/yr instructed per [10 CFR 19.12]? Refresher training provided, as needed [10 CFR 19.12]?

b. Did each gauge operator attend an approved course prior to using gauges?

c. Are training records maintained for each gauge operator?

d. Did interviews with operators reveal that they know the emergency procedures?

e. Did this audit include observations of operators using the gauge in a field situation?

f. Operating gauge? Performing routine cleaning and lubrication? Transporting gauge? Storing gauge?

g. Did the operator demonstrate safe handling and security during transportation, use and storage?

h. HAZMAT training provided as required? [49 CFR 172.700, 49 CFR 172.701,CFR 172.702, 49 CFR *172.703, 49 CFR 172.704]*

4. RADIATION SURVEY INSTRUMENTS

a. If the licensee possesses its own survey meter, does it meet the NRC's criteria?

b. If the licensee does not possess a survey meter, are specific plans made to have one available?

c. Is the survey meter needed for non-routine maintenance calibrated as required [10 CFR 20.1501]?

d. Are calibration records maintained [10 CFR 20.2103(a)]?

5. GAUGE INVENTORY

a. Is a record kept showing the receipt of each gauge? [10 CFR 30.51(a)(1)]

b. Are all gauges received physically inventoried every six months?

c. Are records of inventory results with appropriate information maintained?

6. PERSONNEL RADIATION PROTECTION

a. Are ALARA considerations incorporated into the radiation protection program? [10 CFR 20.1101(b)]

b. Is documentation kept showing that unmonitored users receive <10% of limit?

c. Did unmonitored users' activities change during the year which could put them over 10% of limit?

d. If no to c. above, was a new evaluation performed?

e. Is external dosimetry required (user receiving >10% of limit)? And is dosimetry provided to users?

f. Is the dosimetry supplier *NVLAP* approved? *[10 CFR 20.1501(c)]*

g. Are the dosimeters exchanged monthly for film badges and at industry recommended frequency for TLDs?

h. Are dosimetry reports reviewed by the RSO when they are received?

i. Are the records NRC Forms or equivalent? [10 CFR 20.2104(d), 10 CFR 20.2106(c)]

j. NRC-4 "Cumulative Occupational Exposure History" completed?

k. NRC-5 "Occupational Exposure Record for a Monitoring Period" completed?

l. If a worker declared her pregnancy, did licensee comply with [10 CFR 20.1208[?

m. Were records kept of embryo/fetus dose per 10 CFR 20.2106(e)?

n. Are records of exposures, surveys, monitoring, and evaluations maintained? [10 CFR 20.2102, 10 CFR 20.2103, 10 CFR 20.2106]

7. PUBLIC DOSE

a. Are gauges stored in a manner to keep doses below 100 mrem in a year? [10 CFR 20.1301(a)(1)]

b. Has a survey or evaluation been performed per *10 CFR 20.1501(a)*? Have there been any additions or changes to the storage, security, or use of surrounding areas that would necessitate a new survey or evaluation?

c. Do unrestricted area radiation levels exceed 2 mrem in any one hour? *[10 CFR 20.1301(a)(2)]*

d. Are gauges being stored in a manner that would prevent unauthorized use or removal? *[10 CFR 20.1801]*

e. Are records maintained? *[10 CFR 20.2103, 10 CFR 20.2107]*

8. OPERATING AND EMERGENCY PROCEDURES

a. Have operating and emergency procedures been developed?

b. Do they contain the required elements?

c. Does each operator have a current copy (telephone numbers) of the operating and emergency procedures?

9. LEAK TESTS

a. Was each sealed source leak tested every 6 months or at other prescribed intervals?

b. Was the leak test performed as described in correspondence with NRC and according to the license?

c. Are records of results retained with the appropriate information included?

d. Were any sources found leaking, and if yes, was NRC notified?

10. MAINTENANCE OF GAUGES

a. Are manufacturer's procedures followed for routine cleaning and lubrication of gauge?

b. Does the source or source rod remain attached to the gauge during cleaning?

c. Is non-routine maintenance performed where the source or source rod is detached from the gauge? If yes, was it performed according to license requirements (e.g., extent of work, individuals performing the work, procedures, dosimetry, survey instrument, compliance with 10 CFR 20.1301 limits)?

11. TRANSPORTATION

a. Are DOT-7A or other authorized packages used? [49 CFR 173.415, 49 CFR 173.416(b)]

b. Are package performance test records on file?

c. Are special form sources documentation? [49 CFR 173.476(a)]

d. Does package have 2 labels (ex. Yellow-II) with TI, Nuclide, Activity, and Hazard Class? [49 CFR 172.403, 49 CFR 173.441]

e. Is package properly marked? [49 CFR 172.301, 49 CFR 172.304, 49 CFR 172.310, 49 CFR 172.324]

f. Is package closed and sealed during transport? [49 CFR 173.475(f)]

g. Are shipping papers prepared and used? [49 CFR 172.200(a)]

h. Do shipping papers contain proper entries? {Shipping name, Hazard Class, Identification Number (UN Number), Total Quantity, Package Type, Nuclide, RQ, Radioactive Material, Physical and Chemical Form, Activity, category of label, TI, Shipper's Name, Certification and Signature, Emergency Response Phone Number, Cargo Aircraft Only (if applicable)} [49 CFR 172.200, 49 CFR 172.201, 49 CFR 172.202, 49 CFR 172.203, 49 CFR 172.204, 49 CFR 172.604]

i. Are shipping papers within driver's reach, and readily accessible during transport? [49 CFR 177. 817(e)]

j. Are they secured against movement? [49 CFR 177. 834]

k. Are they placarded on vehicle, if needed? [49 CFR 172.504]

l. Are there proper overpacks, if used? [49 CFR 173.25]

m. Are there any incidents reported to DOT? [49 CFR 171.15, 16]

12. AUDITOR'S INDEPENDENT SURVEY MEASUREMENTS (IF MADE)

Describe the type, location, and results of measurements. Does any radiation level exceed regulatory limits?

13. NOTIFICATION AND REPORTS

a. Was any radioactive material lost or stolen? Were reports made? [10 CFR 20.2201, 10 CFR 30.50]

b. Did any reportable incidents occur? Were reports made? [10 CFR 20.2202, 10 CFR 30.50]

c. Did any overexposures and high radiation levels occur? Were they reported? [10 CFR 20.2203, 10 CFR 30.50]

d. If any events (as described in items a through c above) did occur, what was the root cause? Were corrective actions appropriate?

e. Is the licensee aware of telephone number for NRC Emergency Operations Center? [(301) 816-5100

14. RECORD KEEPING FOR DECOMMISSIONING

a. Are records kept of information important to decommissioning? [10 CFR 30.35(g)]

b. Do records include all information outlined? [10 CFR 30.35(g)]

15. BULLETINS AND INFORMATION NOTICES

a. Have any NRC Bulletins, NRC Information notices, NMSS Newsletters been received?

b. Has appropriate training and action been taken in response?

16. SPECIAL LICENSE CONDITIONS OR ISSUES

a. Did auditor review special license conditions or other issues (e.g., non-routine maintenance)?

17. DEFICIENCIES IDENTIFIED IN AUDIT; CORRECTIVE ACTIONS

a. Summarize problems/deficiencies identified during audit.

b. If problems/deficiencies identified in this audit, describe corrective actions planned or taken. Are corrective actions planned or taken at ALL licensed locations (or just location audited)?

c. Provide any other recommendations for improvement.

18. EVALUATION OF OTHER FACTORS

a. Is senior licensee management appropriately involved with the radiation protection program and/or Radiation Safety Officer (RSO) oversight?

b. Does RSO have sufficient time to perform his/her radiation safety duties?

c. Does Licensee have sufficient staff to support the radiation protection program?

CP014.1

INVENTORY OF RADIOACTIVE MATERIALS AND DEVICES SAMPLE TRACKING FORM

Description of Device/Material	Serial Number	Office Location	License/Permit No.

1. PURPOSE

TRC's Trench and Excavation Compliance Program has been developed based on the Occupational Safety and Health Administration (OSHA) standards for the construction industry (29 CFR 1926, Subpart P – Excavations).

2. SCOPE

This Compliance Program applies to all open excavations made in the earth's surface. Excavations are defined to include trenches. These guidelines apply to all Operating Unit facilities and project sites.

3. DEFINITIONS

<u>Accepted engineering practices</u>: Those requirements which are compatible with standards of practice required by a registered professional engineer.

<u>Aluminum Hydraulic Shoring</u>: A pre-engineered shoring system comprised of aluminum hydraulic cylinders (cross braces) used in conjunction with vertical rails (uprights) or horizontal rails (wales). Such system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

<u>Bell-bottom pier hole</u>: A type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

<u>Benching (Benching system)</u>: A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

<u>Cave-in</u>: The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

<u>Competent person</u>: One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

<u>Cross braces</u>: The horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

<u>Excavation</u>: Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

<u>Faces or Sides</u>: The vertical or inclined earth surfaces formed as a result of excavation work.

<u>Failure</u>: The breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere: An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kick-out: The accidental release or failure of a cross brace.

Protective system: A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp: An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer: A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting: The members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system): A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system): A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation, and which is designed to prevent cave-ins.

Sloping (Sloping system): A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock: Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp: A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system: A structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data: Tables and charts approved by a registered professional engineer, and used to design and construct a protective system.

Trench (Trench excavation): A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box: See Shield.

Trench shield: See Shield.

Type A soil: Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of cohesive soils are clay, silty clay, sandy clay, clay loam, and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hard pan are also considered Type A. However, no soil is Type A if:

- The soil is fissured.
- The soil is subject to vibration from heavy traffic, pile driving, or similar effects.
- The soil has been previously disturbed.
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater.
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B soil**:** Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; granular cohesion less soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and in some cases, silty clay loam and sandy clay loam; previously disturbed soils except those that would otherwise be classed as Type C soil; soil that meets the unconfined compressive strength or cementation requirements for Type A but is fissured or subject to vibration; dry rock that is not stable; material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C soil: Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; granular soils, including gravel, sand, and loamy sand; submerged soils, including soil from which water is freely seeping; submerged rock that is not stable; material in a sloped, layered system where the layers dip into the excavation at a slope of four horizontal to one vertical (4H:1V) or steeper.

Uprights**:** The vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales: Horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

4. RESPONSIBILITIES

4.1 TRC's National Safety Director is responsible for establishing the Trench and Excavation Program requirements and providing/communicating them to the Health and Safety Network. The National Safety Director will review contract documents as required that include project and Client-Specific Requirements.

4.2 The Health and Safety Network is responsible for the Trench and Excavation Program implementation including, but not limited to:

- Qualifying or identifying Competent Person(s) for trench and excavation safety.
- Training new and existing TRC employees.
- Communicating and coordinating TRC's Trench and Excavation Program requirements with all TRC subcontractors, including identification of Subcontractor(s) Competent Person(s).
- Procuring TRC health and safety equipment (harnesses, lanyards, vertical and horizontal lifeline and other materials).
- Working in conjunction with identified Competent Person(s) to provide on-site direction on Trench and Excavation issues.
- Leading all investigations along with the Competent Person, Project Manager, Field Team Leader, and subcontractor health and safety representative or their designees, if a Trench and Excavation Program violation occurs on-site.
- Assisting in Trench and Excavation Program audits in conjunction with on-site TRC subcontractor, and the health and safety representatives or their designees.
- Maintaining records for health and safety activities on-site including equipment inspections and procedural audits of employee Trench and Excavation Program implementation.
- Coordinating assistance during emergency situations.

4.3 OSHA defines a Competent Person as one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, who has authorization to take prompt corrective measures to eliminate them (29 CFR 1926.32[f]). By way of training and/or experience, a Competent Person is knowledgeable of applicable standards, and is capable of identifying workplace hazards related to the specific operation. Under TRC's Trench and Excavation Program the Competent Person will:

- Perform all duties as specified in the Trench and Excavation Program.

- Review and approve all Health and Safety Plans (HASPs) and Job Safety Analyses (JSAs) that include work in and around trenches and excavations.
- In the event of simultaneous operations, cooperate fully with the Subcontractor's Person in Charge.
- Communicate with performing authorities (i.e., employees working in or around trenches or excavations) regarding the presence of other operations on-site.
- Work with Project Manager and/or Field Team Leader to identify and manage the risks associated with the project site.
- Assist in the training of employees who will be performing tasks in and around a trench or excavation.
- Ensure that a rescue plan is established by working with the Project Manager and/or facility safety personnel prior to any employees entering or working around a trench or excavation.
- Provide guidance as required for Trench and Excavation Program issues and questions.
- Coordinate with Project Managers and Health and Safety Network on trench and excavation audits.
- Observe the implementation of Trench and Excavation Program and conduct audits as required or directed.

4.4 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the Trench and Excavation Program. Project Managers must hold all TRC and other project employees working on-site accountable (zero tolerance policy) for maintaining a safe work environment.

4.5 Project Managers and site employees shall be held accountable for performing work in a safe manner according to the requirements of the Trench and Excavation Program.

4.5.1 The Field Team Leader shall:

- Participate in Trench and Excavation Awareness training.
- Confirm that Competent Personnel prepared and/or reviewed the Site-Specific Rescue Plan if required.
- When required, confirm that everyone working under a specific permit adheres to the permit's documented conditions.

5. PROCEDURE

5.1 General Requirements Permit labor

The following guidelines establish the minimum requirements of the applicable state and federal safety regulations for all work in excavations and trenches that might expose employees to the hazards of moving ground:

- All surface encumbrances adjacent to an excavation that might create a hazard to employees must be removed, secured, or supported as necessary to protect employees.
- The estimated location of underground installations, such as sewer, telephone, electric, water, or other underground utilities must be identified before opening an excavation. Utility companies, owners, and local One Call locator services must be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations before the work begins.
- When excavations approach the estimated location of underground installations, the exact location is determined by probing or hand digging, as necessary, to prevent accidental contact with the underground installations. While the excavation is open, underground installations that create a hazard to employees will be supported, protected, or removed as necessary to protect employees.

5.1.1 Access and Egress - Structural ramps.

- Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.
- Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.
- Structural members used for ramps and runways shall be of uniform thickness.
- Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.
- Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments o the top surface to prevent slipping.
- Appropriate access and egress in the form of a stairway, ladder, or ramp must be provided in all excavations deeper than 4 feet (1.23 m). In trenches, the stairway, ladder, or ramp must be installed so that a worker does not have to travel farther than 25 feet (7.62 m) in any direction to exit.

- Employees exposed to vehicular traffic must wear safety vests or other equivalent apparel marked with or made of reflectorized or high-visibility material.
- No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.
- A warning system must be provided when mobile equipment is operated adjacent to an excavation and the operator does not have a clear and direct view of the edge of the excavation. The warning system may include barricades, signals, stop logs, or other authorized methods. If possible, the grade should be away from the excavation.
- When deemed necessary by a competent person, excavations where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.
- When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.
- Emergency rescue equipment, such as rescue breathing apparatus, a safety harness and line, or a basket stretcher must be available where a hazardous atmosphere exists or could be expected to develop in an excavation.
- Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.
- Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

- If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.
- Inspection of an excavation shall be made by a competent person when accumulation of water is present.
- If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person.
- The stability of adjacent structures, such as buildings, walls, and sidewalks must be maintained using a support system as necessary to protect employees.
- Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:
  - A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
  - The excavation is in stable rock; or
  - A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or
  - A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.
- Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.
- Employees must be protected from loose rock or soil that could fall or roll into the excavation by placing and keeping such material at least 2 feet (0.61 m) from the edge of the excavation.
- A competent person must make daily inspections of excavations to identify and eliminate conditions that could result in cave-ins, failure of support systems, hazardous atmospheres, or other unsafe conditions. Inspections must be conducted before the start of work each day and after every rainstorm or other occurrence that might increase the hazard of moving ground. If problems are found, provisions should be made for immediate removal of personnel.

- Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.
- Where employees or equipment are allowed or required to cross over excavations that are 6 feet
- (1.83 m) or greater in depth, appropriate fall protection in the form of walkways or bridges with standard guardrails must be provided.
- An open excavation or trench that is left open overnight must be barricaded, covered, and secured in a manner that prevents anyone from entering the excavation intentionally or accidentally.

5.2 Protective Systems

Sloping, shoring, or shielding will be provided in excavations, except where the excavation is made in stable rock or the excavation is less than 5 feet (1.52 m) deep and an examination by a competent person does not indicate a potential for cave-in.

5.3 Sloping

When sloping or benching is chosen as the method to protect employees in an excavation, one of the following optional designs of sloping and benching systems must be used:

- Option 1 – Slope the excavation at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal).
- Option 2 – Perform a soil classification and determine the acceptable slopes required.
- Option 3 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and must include the name and registration number of the engineer, detailed plans, the calculations used in the design, the magnitude of slopes, and the configurations determined to be safe. A copy of the design will be maintained at the jobsite during the use of the engineered system.

5.4 Shoring or Shielding

Only the following methods for support systems, shield systems, and other protective systems can be used at a TRC jobsite:

- Option 1 – Perform a soil classification and determine the appropriate support, shield or other protective system configuration using the shoring manufacturer's tabulated data.

When using the manufacturer's tabulated data, the shoring system must be installed in accordance with all the specifications, recommendations, limitations, or approvals to deviate issued by the manufacturer. The manufacturer's tabulated data, specifications, recommendations, limitations, and any approval to deviate must be in writing, and maintained at the jobsite during the use of the shoring system.

- Option 2 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and include the name and registration number of the engineer, detailed plans, the calculations used in the design, and the sizes, types, and configurations of materials to be used in the support system. A copy of the design must be maintained at the jobsite during the use of the engineered system.

5.5 General Guidelines

The materials and equipment used for protective systems must be free of damage or defects that might impair their proper functions. Manufactured materials and equipment must be used and maintained in accordance with the recommendations of the manufacturer. If material or equipment used in a protective system is damaged, it must be inspected by a competent person before being reused.

The installation and removal of protective systems must be performed in accordance with all of the following guidelines:

- Members of support systems must be securely fastened together to prevent sliding, falling, kick-outs, or other predictable failures.
- Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or being struck by members of the support system.
- Individual members of support systems must not exceed their design capacities.
- Before individual members can be removed, additional precautions must be taken to protect employees, including installing other structural members to support any additional load imposed on the support system.
- Removal begins at, and progresses from, the bottom of the excavation. Members must be released slowly to reduce the likelihood of failure of the remaining members or a cave-in.
- Backfilling must progress with the removal of support systems.
- Support systems must be coordinated with the excavation of trenches and must extend to within 2 feet (0.61 m) of the bottom of the trench, but only if the system is designed to resist the forces calculated for the full depth of trench, and there is no indication of a loss of soil from behind or below the bottom of the support system.

- Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.
- Shield systems must not be subjected to loads exceeding their design capacities. Shields must be installed in a manner that restricts lateral or hazardous movement in the event that a lateral load is applied suddenly. Employees must be protected when entering or exiting the areas protected by a shield. Employees are not allowed within the shield during installation, removal, or vertical movement.
- When shield systems are used in trenches, excavation of material may proceed 2 feet (0.61 m) below the bottom of the shield only if the shield is designed to resist the forces calculated for the full depth of trench and there is no indication of a loss of soil from behind or below the bottom of the shield.

5.6 Soil Classification

This section describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits.

- Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C, in accordance with the definitions set forth in this compliance program.
- Soil and rock deposits are classified based on the results of at least one visual and one manual analysis. These analyses must be conducted by a competent person using the tests described in this chapter or other approved methods of soil classification, such as those adopted by the American Society for Testing Materials (ASTM) or the United States Department of Agriculture (USDA).
- The methods used for visual and manual analyses must provide quantitative and qualitative information sufficient to identify the properties, factors, and conditions of the deposits.
- A layered system must be classified based on the weakest layer. However, each layer may be classified individually when a more stable layer lies below a less stable layer.
- If, after classifying a deposit, the properties, factors, or conditions change in any way, the changes must be evaluated by a competent person. The deposit must be reclassified as necessary to reflect the new circumstances.

5.7 Visual Analysis

The visual analysis is conducted to collect qualitative information about the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the excavation, and soil samples taken from the excavated material. The visual analysis includes:

- Observing samples of the soil that are excavated and soil in the sides of the excavation to estimate the range of particle sizes and the relative amounts of particle sizes. Fine-grained material is cohesive.
- Observing the soil as it is excavated to determine if it stays in clumps. Soil that breaks up easily and does not stay in clumps is granular.
- Observing sides of the opened excavation and the surface area adjacent to the excavation to identify tension cracks or fissured material.
- Observing the area adjacent to the excavation and the excavation itself to identify existing underground utilities, structures, or previously disturbed soils.
- Observing the opened sides of the excavation to identify layered systems. Examine layered systems to determine if the layers slope toward the excavation, and to estimate the degree of slope in the layers.
- Observing the area adjacent to the excavation and the areas within the excavation to identify potential sources of vibration that might affect the stability of the excavation.
- Observing the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the water table.

5.8 Manual Analysis

Manual analysis is conducted to collect quantitative and qualitative information about the properties of the soil, and to provide more information to properly classify the soil. The manual analysis includes some or all of the following methods:

- Evaluating the plasticity of the soil by molding a moist or wet sample of soil into a ball and attempting to roll it into threads as thin as 1/8 inch (0.32 cm) in diameter. Cohesive material can be rolled into a thread at least 2 inches (5.08 cm) long without crumbling or breaking.
- Evaluating the cohesiveness of the soil. If the soil is dry and crumbles into individual grains or fine powder with little or moderate pressure, it is granular. If the soil is dry and falls into clumps that break into smaller clumps but the smaller clumps can only be broken up with difficulty, it might be clay in combination with gravel, sand, or silt. If the dry soil breaks into small clumps that can only be broken with difficulty and there is no visual indication the soil is fissured, the soil may be considered unfissured.

- Applying the thumb penetration test to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb and can be molded by light finger pressure.
- The thumb test should be conducted on an undisturbed soil sample, such as a large clump of soil, as soon as possible after excavation to minimize the effects of drying. If the excavation is later exposed to rain, flooding, or other moisture, the classification of the soil must be changed accordingly.
- Estimating the unconfined compressive strength of soils by using a pocket penetrometer or a hand-operated shear vane in accordance with the manufacturer's recommendations.
- Performing a drying test to differentiate among cohesive material with fissures, unfissured cohesive material, and granular material. After thoroughly drying a sample of soil that is approximately 1 inch (2.54 cm) thick and 6 inches (15.24 cm) in diameter, evaluate the results as follows:
  - If the sample develops cracks as it dries, significant fissures are indicated.
  - If the sample dries without cracking and can be broken by hand, then the material is either unfissured cohesive or fissured cohesive.
  - If considerable force is necessary to break the sample, the soil has significant cohesive material content. The soil can be classified as unfissured cohesive material, and the unconfined compressive strength should be determined.
  - If the sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

5.9 Sloping and Benching Specifications

This section contains the specifications for using sloping and benching to protect employees working in excavations.

- These slope and bench specifications only apply if a soil classification has been conducted and the excavation will be 20 feet (6.10 m) deep or less.
- Determine the maximum allowable slope and configuration based on the soil classification by using the information in table(s) 1, 2 and 3.

Table 1 Maximum Allowable Slope Based on Soil Classification

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)(1) FOR EXCAVATIONS LESS THAN 20 FEET DEEP(3)
STABLE ROCK	VERTICAL (90º)
TYPE A(2)	3/4:1 (53º)
TYPE B	1:1 (45º)
TYPE C	1½:1 (34º)

1. The numbers shown in parentheses next to the maximum allowable slopes are angles expressed in degrees from the horizontal. The angles have been rounded off.
2. A short-term, maximum slope of 1/2:1 (63 degrees) is allowable in excavations in Type A soil less than 12 feet (3.66 m) deep. The short-term maximum allowable slopes for excavations deeper than 12 feet (3.66 m) is 3/4 (53 degrees).
3. Sloping or benching for excavations deeper than 20 feet (6.10 m) must be designed by a registered professional engineer.

Table 2 Excavations in Type A, B, and C Soils

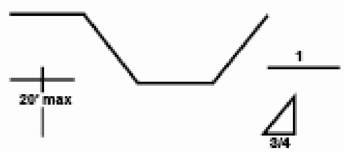
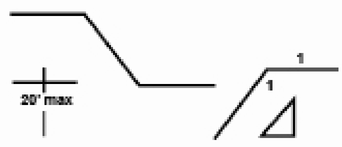
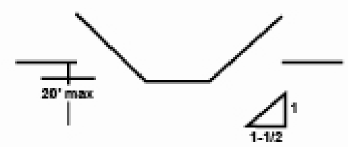
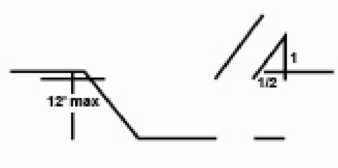
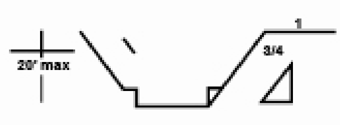
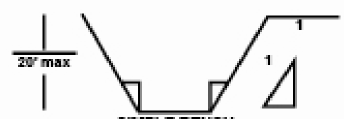
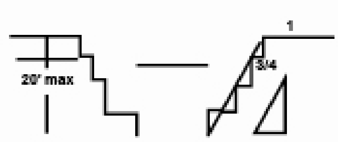
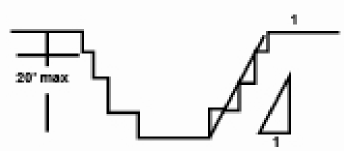
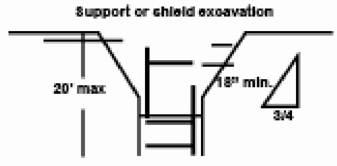
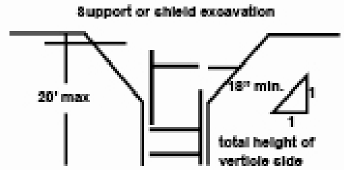
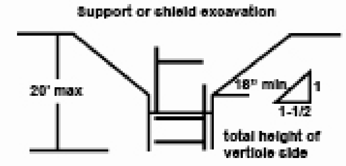
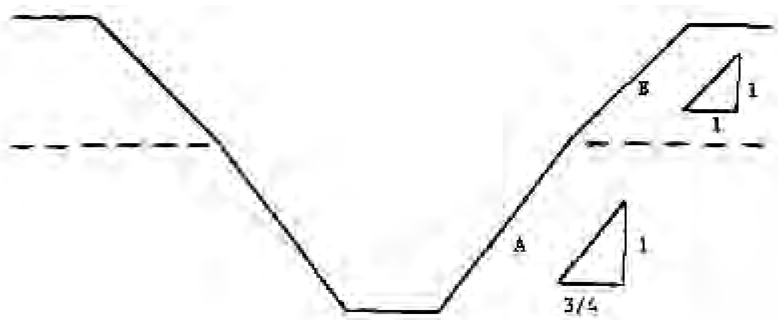
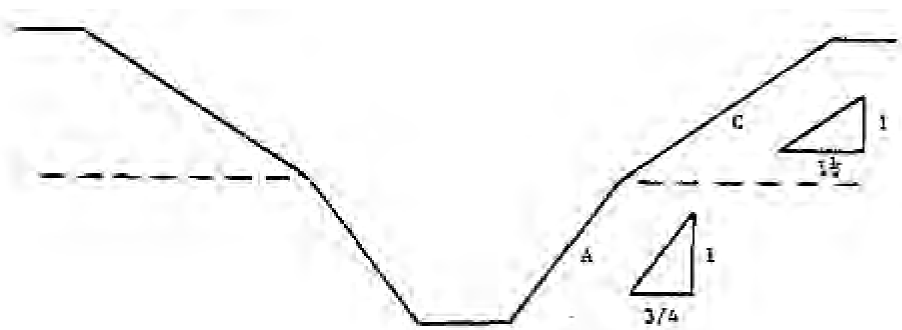
EXCAVATIONS IN TYPE A SOIL	EXCAVATIONS IN TYPE B SOIL	EXCAVATIONS IN TYPE C SOIL
SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1  SIMPLE SLOPE
EXCEPTION: SHORT-TERM SIMPLE SLOPES LESS THAN 12 FEET DEEP HAVE A MAXIMUM SLOPE OF 1/2:1  SIMPLE SLOPE SHORT-TERM		
BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE BENCH	BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
 MULTIPLE BENCH	 MULTIPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1. Support or shield excavation  SUPPORTED LOWER PORTION
THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.

Table 3 Excavations Made in Layered Soils

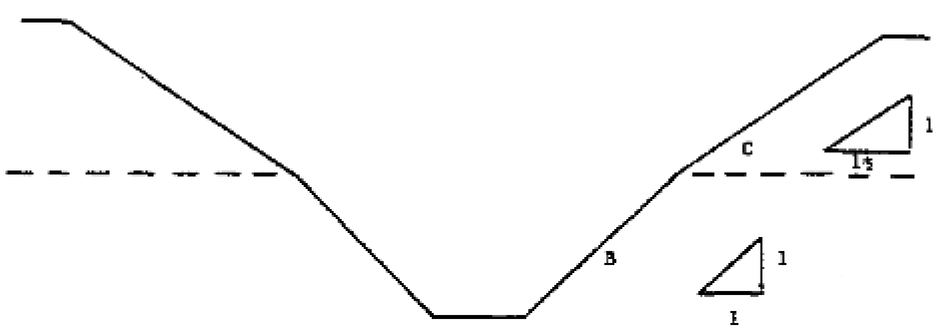
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



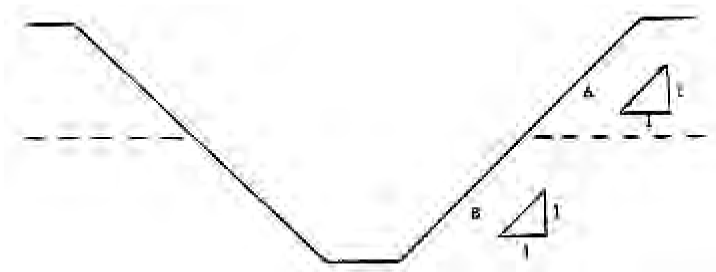
B OVER A



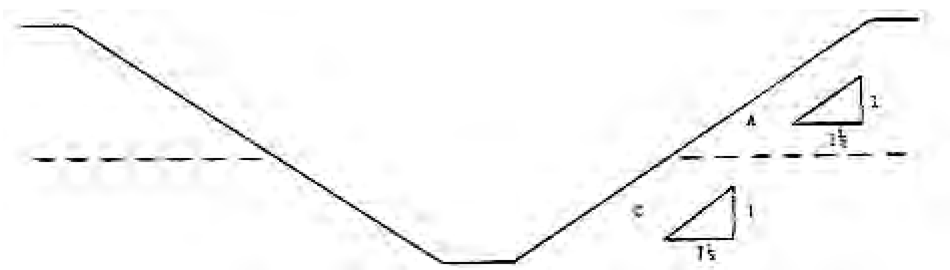
C OVER A



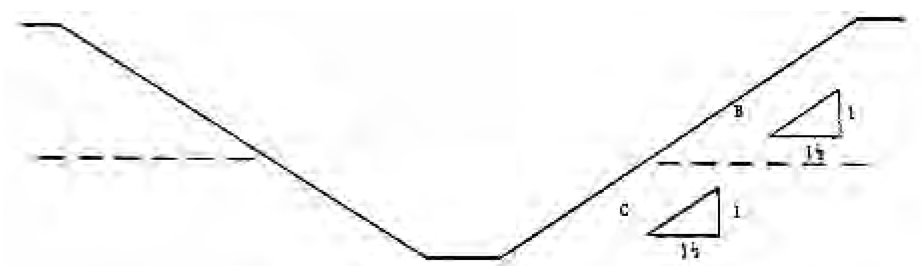
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

6. REFERENCES / RELATED DOCUMENTS:

29 CFR 1926 Subpart P, Excavations

CP002 – Risk Analysis Site Specific Health and Safety Program

CP003 – Personal Protective Equipment Program

CP008 – Confined Space Entry Program

CP009 – Health and Safety Training Program

7. APPENDICES

Forms

A. TRC Site-Specific Excavation Plan
B. TRC Pre-Excavation Checklist
C. TRC Excavation Inspection Form
D. TRC Protective Systems Selection Flow Chart

FORMS

A. **TRC SITE-SPECIFIC EXCAVATION PLAN**
B. **TRC PRE-EXCAVATION CHECKLIST**
C. **TRC EXCAVATION INSPECTION FORM**
D. **TRC PROTECTIVE SYSTEMS SELECTION FLOW CHART**

Site Specific Excavation Plan

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

Surface Encumbrances

Have Surface encumbrances that may create a hazard been removed or supported?

☐ Yes

☐ N/A

Underground Installations

Have Utility companies or owners been contacted? ☐ Yes ☐ N/A

By whom: Work Order #: Date:

When excavation operations approach the estimated location of underground installations, how will the exact location of the installations shall be determined?

☐ Probing ☐ Hand digging ☐ Detecting equipment ☐ Other

How will underground installations be protected?

☐ Support ☐ Removal ☐ Other

Access and Egress

Will structural ramps be used? ☐ Yes ☐ N/A

Designed by a competent person? ☐ Yes ☐ N/A

Will excavations be 4 feet in depth or more? ☐ Yes ☐ N/A

Means of egress (requiring no more than 25 feet of lateral travel) ☐ Yes ☐ N/A

☐ Stairway(s) ☐ Ramp(s) ☐ Ladder(s) ☐ Other

Exposure to vehicular Traffic? ☐ Yes ☐ N/A (If yes workers shall wear warning vests or other suitable garments.)

Exposure to falling loads? ☐ Yes ☐ N/A

☐ No workers permitted underneath loads

☐ Workers shall be required to stand away from any vehicle being loaded or unloaded. (Operators may remain in cabs)

Warning System for Mobile Equipment

Will mobile equipment operated adjacent to, or approaching the edge of, excavations have a clear and direct view of the edge of the excavation?

☐ Yes ☐ N/A If yes what warning system will be utilized?

☐ Barricade(s) ☐ Hand Signals ☐ Stop logs ☐ Other

Hazardous Atmospheres

Can oxygen deficiency or a hazardous atmosphere reasonably be expected to exist? ☐ Yes ☐ N/A

If yes, how will atmospheres in excavations greater than 4 feet in depth be tested?

If atmospheres contain less than 19.5% oxygen or other hazardous substance how will it be remediated?

When controls are intended to reduce the level of contaminants to acceptable levels, testing shall be conducted:

☐ Continuously ☐ Periodically

Will emergency rescue equipment be utilized? ☐ Yes ☐ N/A If yes what type?

☐ SCBA ☐ Harness and line ☐ Basket stretcher ☐ Other

Site Specific Excavation Plan

Water Accumulation

Will workers work in excavations in which there is accumulated water? ☐ Yes ☐ N/A

If yes is water controlled or prevented from accumulating by water removal equipment? ☐ Yes ☐ N/A

Equipment type: Competent Person:

Does excavation work interrupt the natural drainage of surface water (such as streams)? ☐ Yes ☐ N/A

Method used to divert water:

Stability of Adjacent Structures

Will the stability of adjacent structures be endangered by excavation operations? ☐ Yes ☐ N/A

If yes, what type of support structure will be used?

☐ Shoring ☐ Bracing ☐ Underpinning ☐ Other

If yes, but support structures will not be used, one of the following must apply:

☐ The excavation is in stable rock

☐ A registered professional engineer has determined that such work will not pose a hazard.

Name of registered professional engineer:

Protection from Loose Rock or Soil

How will workers be protected from materials or equipment that could fall or roll into excavations?

☐ Material placed > 2 feet from edge Retaining devices

Inspections

☐ Inspections of all excavations, adjacent areas and protective systems shall be made by a competent person.

☐ Inspections shall be conducted by the competent person daily, prior to the start of work and as needed throughout the shift. Inspections shall be documented on a Daily Excavation Inspection Form.

☐ Inspections shall be made after every rainfall or other hazard increasing occurrence.

☐ Where the competent person finds evidence of hazardous conditions, workers shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

Fall Protection

Will excavations be 6 feet or greater in depth? ☐ Yes ☐ N/A

If yes, fall protection will consist of:

☐ Barricades ☐ Fall restraint ☐ Harness ☐ Other

Will workers be required or permitted to cross over excavations? ☐ Yes ☐ N/A

If yes, guardrails shall be provided.

SIGNATURES

Supervisor	General Supervisor
Project/Construction Manager	Safety Representative

Pre-Excavation Checklist

Know what's below. Call before you dig.

Project Name: **Project #:**
Location: **Date:**
Company: **One Call #**
Submitted By:

The following procedures are mandatory. Failure to complete this check list could result in disciplinary action or termination:

Complete a pre-excavation walk-out of the entire job site. Your objective is to visually inspect the dig area to ensure all utilities are marked. Look for obvious signs of utilities in the immediate work area that may not be marked such as, above-ground pedestals, gas meters, man-hole covers, drains, or utility poles with cable risers. If you find these indicators and suspect that there is an unmarked utility DO NOT PROCEED**. Call your General Foreman or Locate Ticket Coordinator immediately.**

When you have completed your walk-out, complete the following check list:

1. Verify that the One-Call ticket covers the 'Scope of work' and 'Work to begin' date:

   I have verified the One-Call ticket covers the 'Scope of work' &'Work to begin' date ☐

2. What marked utilities did you observe?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

3. Based on visual observation, did you see any obvious signs of unmarked utilities in the immediate work area?

   ☐Yes ☐No If Yes, please identify?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

4. I have notified my Supervisor and Locate Ticket Coordinator ☐
5. Photograph the entire proposed work area including all locate marks.

   I have photographed the entire site including existing locate/markings prior to excavation ☐

6. Advise your crew members of the following: If they have to cross a marked Utility they must HAND DIG ONLY within 18" of the locate marks. For gas lines add half the diameter of the buried facility to the 18''. If necessary, dig a test-hole (pothole) using hand tools to determine the location of the facility.

   I have advised my crew of this rule ☐

7. When possible, all directional boring / drilling routes must be potholed every 50-80 feet prior to drilling.

   I have advised my crew accordingly and test-holes (potholes) have been dug ☐

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ RESPECT THE MARKS! ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

IN THE EVENT OF DAMAGE

- Notify your Supervisor and Locate Ticket Coordinator
- Complete the TRC Incident Notification Form
- Photograph entire area and damage location

PHOTOGRAPHY TIPS

- Make sure the correct date & time stamp is active on your camera
- Photograph the excavation itself (damage location) and cable depth (include tape measure in hole)
- Take photos from multiple vantage points and of surrounding area (360 degrees)
- If the utility was miss-marked, photograph the locate marks/flags (include tape measure in photo)
- If the utility was not marked, photograph the entire area and approaches to the cut site
- Show a quantifiable location/address (street sign, house number, mail box number etc.)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Excavation Flow Diagram

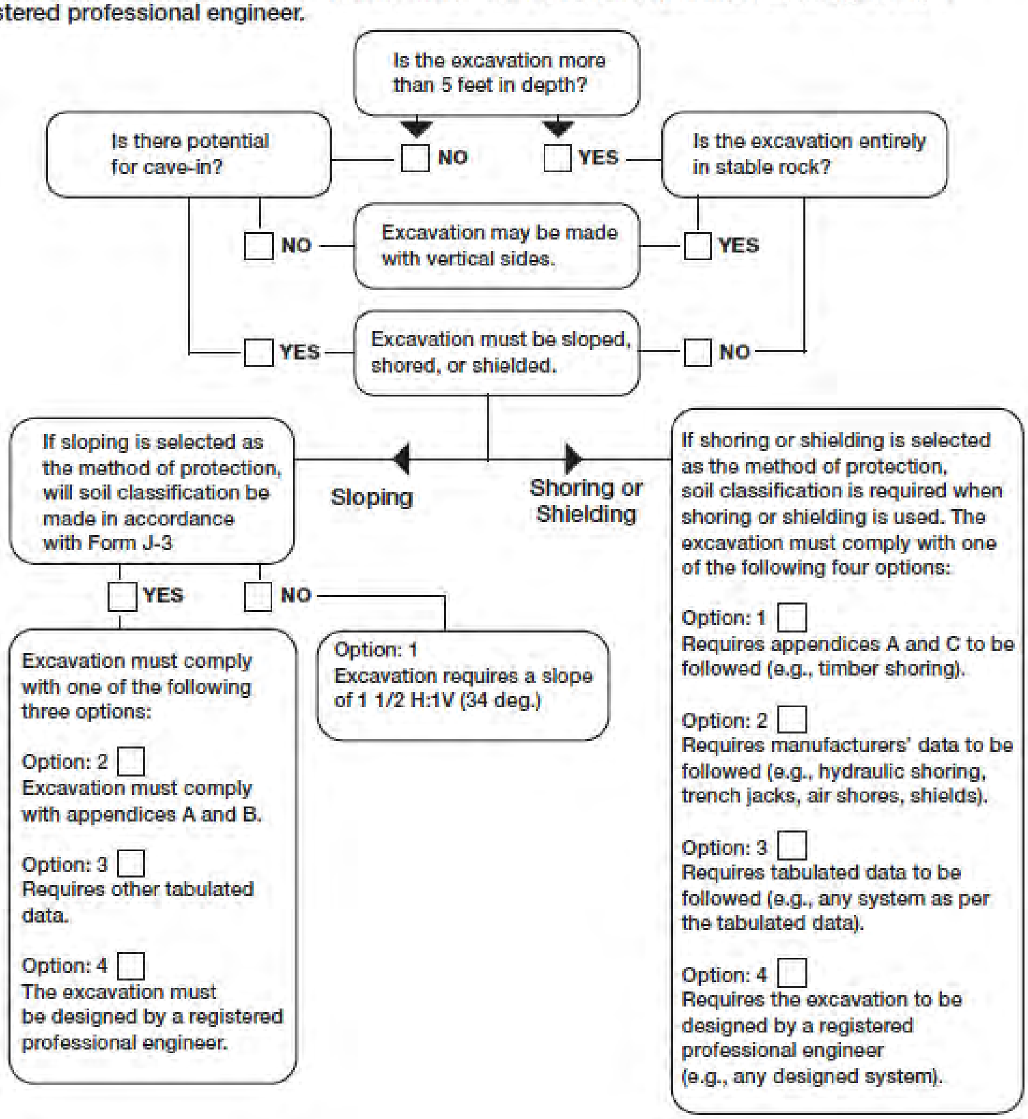
Project Name: **Project #:**

Location: **Date:**

Company:

Submitted By:

The following is a graphic summary of the requirements for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer.



Excavation Daily Inspection

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

Depth: ________________________ **Width:** _______________________ **Date Opened:** _____________________

Soil classification: ☐ A ☐ B ☐ C

Indicate how the classification was made:

Manual test(s)

	A	B	C
a) plasticity	________	________	________
b) dry strength	________	________	________
c) thumb penetration	________	________	________
d) pocket penetrometer	________	________	________
e) other	________	________	________

Visual test(s) **Do as many as possible**	**Cohesive Soil**	**Granular Soil**
a) Spoil pile	☐ **Remains in clumps**	☐ **Breaks up easily**
b) Trench Side	☐ **Stands vertical >2 hours**	☐ **Sloughs into trench**

The excavation is properly (circle one):

Shored/Shielded	**(indicate type of shoring)**	☐ **closed**	☐ **open**	☐ **wood**	☐ **metal**	☐ **shield**
Sloped/benched	**(indicate the slope)**	☐ **vertical sides**	☐ **3/4:1**	☐ **1:1**	☐ **1 1/2: 1**	☐ **2:1**

Excavation Checklist:	Morning	Mid-Day	Afternoon
Time:	________	________	________
Weather:	________	________	________
Was atmospheric testing required?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Was atmospheric testing done?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is the spoil pile back 2' from the edge?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Have surface encumbrances been removed?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Are there any signs of sloughing or cave-in?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is there water accumulation in the bottom?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Are there vibration sources near the excavation?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is there adequate access/egress (ladder, ramp, etc.)	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Has the soil been disturbed previously?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Sides	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Top	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
If the excavation is > 20 feet deep, have engineering designs been documented and complied with?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**

SIGNATURES

Supervisor | General Supervisor

Project/Construction Manager | Safety Representative

1. PURPOSE

This compliance program establishes the requirement of various types, setup, maintenance, and uses of signs, signals, and barricades mandated by the Occupational Safety and Health Administration (OSHA) standards for the construction industry (29 CFR 1926, Subpart G- Signs, Signals, and Barricades).

2. SCOPE

Signs and symbols required by this subpart shall be visible at all times when work is being performed, and must be removed or covered immediately when the hazards are no longer present at the jobsite.

3. DEFINITIONS

Barricade: means an obstruction to deter the passage of persons or vehicles.

Signs: are the warnings of hazard, temporarily or permanently affixed or placed, at locations where hazards exist.

Signals: are moving signs, provided by workers, such as flaggers, or by devices, such as flashing lights, to warn of possible or existing hazards.

Tags: are temporary signs, usually attached to a piece of equipment or part of a structure, to warn of existing or immediate hazards.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for administering this compliance program for TRC and evaluating the effectiveness of this program at least annually to verify the program remains effective.

4.2 The Corporate Safety Manager, in consultation with TRC's Training Administrator, is responsible for making signs, signals, and barricades training available to employees.

4.3 Office Safety Coordinators are responsible for assisting Project Managers with implementing this compliance program and develop site-specific Health and Safety Plans (HASPs) when required.

4.4 The Project Manager, in consultation with TRC's Safety Network, is responsible for assessing the risks of a project including identification selecting the proper control methods when employees will be performing tasks that require the use of signs, signals, and/or barricade.

4.5 Employees are responsible for completing training required by this program and implementing the control methods identified by the site-specific HASP, or this compliance program.

5. PROCEDURE

5.1 Accident Prevention Signs and Tags

- Danger signs:
  - o Shall be used only where an immediate hazard exists, and shall follow the specifications illustrated in Figure 1 below.

Figure 1

  - o Shall have red as the predominating color for the upper panel, black outline on the borders, and a white lower panel for additional sign wording.
- Caution signs:
  - o Shall be used only to warn against potential hazards or to caution against unsafe practices, and shall follow the specifications illustrated in Figure 2.

Figure 2

  - o Shall have yellow as the predominating color, black upper panel and boarders: yellow lettering of "caution" on the black panel, and the lower yellow panel for additional sign wording. Black lettering shall be used for additional wording.
  - o The standard color of the background shall be yellow, and the panel black with yellow letters. Any letters used against the yellow back ground shall be black. The colors shall be those of opaque glossy.

- Exit signs:
  - When required, shall be lettered in legible red letters, not less than 6 inches high, on a white field and the principal stroke of the letters shall be at least three-fourths inch in width (Figure 3).

Figure 3

- Safety instruction signs:
  - When used, shall be white with green upper panel with white letters to convey the principal message. Any additional wording on the sign shall be black letters on the white background (Figure 4).

Figure 4

- Directional signs:
  - Other than automotive traffic signs specified in the Traffic signs section, shall be white with a black panel and a white directional symbol. Any additional wording on the sign shall be black letters on the white background (Figure5).

Figure 5

- Traffic signs:
    - o Construction areas shall be posted with legible traffic signs at points of hazard.
    - o All traffic control signs or devices used for protection of construction workers shall conform to Part VI of the MUTCD, 1988 Edition, Revision 3, or Part VI of the MUTCD, Millennium Edition.
- Accident prevention tags:
    - o Accident prevention tags shall be used as a temporary means of warning employees of an existing hazard, such as defective tools, equipment, etc. They shall not be used in place of, or as a substitute for, accident prevention signs (Figure 6).

Figure 6

5.2 Signaling

- Flaggers: Signaling by flaggers and the use of flaggers, including warning garments worn by flaggers, shall conform to Part VI of the Manual on Uniform Traffic Control Devices (1988 Edition, Revision 3, or the Millennium Edition).
- Crane and hoist signals: Regulations for crane and hoist signaling can be found in applicable American National Standards Institute standards.

5.3 Barricades

Barricades are required around excavations (refer to CP024 Excavation and Trench Program); openings in floors, walls, or roof areas; edges of platforms; and certain types of overhead work.

- Warning barricades:

  Warning barricades offer no physical protection, but serve to alert personnel in the area that a hazard is present.

    - o Warning barricades must be set back 6 feet (1.8 meters) minimum from the hazard.

- If 6 feet (1.8 meters) is not feasible, a protective barricade should be used.
- If the hazard is a potential fall of 6 feet (1.8 meters) or more, the warning barricade must be set back at least 6 feet (1.8 meters), preferably 15 feet (4.6 meters).

- Protective Barricades:

  Protective barricades not only warn of a hazard, but provide physical isolation or protection from the hazard. Examples include guardrails or cables set at the proper height around an opening or edge. Another example is anchored railroad ties to prevent driving into a culvert. Protective barricades must be designed to meet their intended purpose. Presented below are two examples.

  - Example 1: If the barricade is to prevent personnel from walking into a floor hole, it must meet all requirements for a guardrail (top and mid rails and toe board designed to resist a 200-pound (85 kilogram) force.
  - Example 2: If the barricade is to stop equipment from running into a ditch, it must be the equivalent of railroad ties or 6-inch (15.2 centimeters) ID concrete-filled pipe posts, set 3 feet (0.9 meter) deep in concrete, spaced 3 feet (0.9 meter) apart.

- Barricade Tape:

  Barricade tape will be of a color or combination of colors that convey the appropriate level of hazard. Tape will be erected in a secure and neat manner that will maintain a height of between 40 and 45 inches (101.6 and 114.3 centimeters) from the floor or ground surface.

  - Yellow/Black Barricade Tape: This type of barricade tape serves as a caution to indicate to employees that a potential hazard exists. Employees may enter without permission from erector of this tape. This barricade tape is used for, but not limited to, the following:
    - Excavation 1 to 4 feet (0.3 to 1.2 meters) in depth;
    - Identification of trip hazards and low hanging objects; or
    - Material storage on the site.
  - Red Barricade Tape: This type of barricade tape indicates DANGER and that a potential serious hazard may be present. No employee, other than those assigned to work inside a RED barricade, may enter without first obtaining permission from the erector of the tape. This barricade tape is used for, but is not limited to, the following:
    - Excavations 4 feet (1.2 meters) or more in depth;
    - Overhead work;
    - Live electrical components;
    - Scaffold under construction; or

- Around swing radius of equipment with a rotating superstructure.

o Magenta (Purple)/Yellow Tape: This barricade tape is used to indicate DANGER—RADIATION and that possible exposure may be present. This barricade tape is considered an equal to red, in that no employees can enter this area without first obtaining permission from the erector of the tape. This color is representative of x ray work being performed. Signs must also be posted to protect areas where radiation operations are in progress.

5.4 Floor Hole Covers

A floor hole cover conforming to the following is required:

- If one dimension of the opening is 18 inches (45.7 centimeters) or less, use plywood at least3/4 inch (1.9 centimeters) thick.
- If both dimensions of the opening exceed 18 inches (45.7 centimeters), use two layers of 3/4-inch (1.9 centimeter) plywood or material at least 2 inches (5.1 centimeters) thick.

Covers over large floor openings must be constructed to the same loading specification as scaffold decking. Floor hole covers must be secured (cleat, wire, or nail) to prevent displacement. Floor hole covers must be clearly marked with a “Danger – Hole Cover – Do Not Remove” sign.

6. REFERENCES/RELATED DOCUMENTATION

CP002 – Risk Analysis/Site-Specific Health and Safety Program

CP024 – Excavation and Trench Program

29 CFR 1926. Respirable Crystalline Silica

1. PURPOSE

The purpose of this Pandemic Preparedness Program (Program) is to protect our employees' health, improve preparedness and response, and minimize the negative impact on TRC's ability to service clients during a pandemic disease event. This Program will be managed in conjunction with TRC's Business Continuity Plan (BCP) and Crisis Management Committee program.

2. SCOPE

This procedure applies to TRC employees.

3. DEFINITIONS

Pandemic: Refers to an epidemic that has spread over several countries or continents, usually impacting a large number of people. A pandemic includes:

- Healthcare services not being available (they are already full at present with the usual ailments).
- Schools, churches and other public places not being open.
- Borders are partially or fully closed, especially airports, leaving people (our families, employees, business partners, customers and suppliers) "stranded".
- Essential materials and supplies may be limited due to distribution chains that are affected by the travel restrictions or absentee workers supporting those transportation means.
- Essential services around utilities, food distribution/access and banking systems may not be at "normal levels"; access to cash flow could be tight.
- People may not be willing to or able to come to work.

Avian influenza: A virus that infects birds especially poultry and variations have been known to be transmitted to humans. One strain, H5N1 is highly pathogenic to humans and limited vaccine is available.

COVID-19: Commonly referred to as the "coronavirus". COVID-19 is a new coronavirus not previously seen in humans that can cause upper respiratory illness with fever, cough, and difficulty breathing.

Influenza pandemic: Occurs when a new influenza virus emerges and spreads around the world as most people do not have immunity.

H1N1: Commonly referred to as the "swine flu" because it has been found in farm animals and can be transmitted to humans.

Seasonal influenza: Regional common influenza that is routine and vaccines are readily available.

Vaccine: Pre-emptive treatment in the form of a shot or nasal mist specific to a viral strain that increases a person's immunity and ability to resist infection.

US Department of State Travel Advisory Levels: Levels and definitions issued in 2018 by the US Department of State include the following:

- **Level 1 – Exercise Normal Precautions:** This is the lowest advisory level for safety and security risk. There is some risk in any international travel. Conditions in other countries may differ from those in the United States and may change at any time.
- **Level 2 – Exercise Increased Caution:** Be aware of heightened risks to safety and security. The Department of State provides additional advice for travelers in these areas in the Travel Advisory. Conditions in any country may change at any time.
- **Level 3 – Reconsider Travel:** Avoid travel due to serious risks to safety and security. The Department of State provides additional advice for travelers in these areas in the Travel Advisory. Conditions in any country may change at any time.
- **Level 4 – Do Not Travel:** This is the highest advisory level due to greater likelihood of life-threatening risks. During an emergency, the U.S. government may have very limited ability to provide assistance. The Department of State advises that U.S. citizens not travel to the country or leave as soon as it is safe to do so. The Department of State provides additional advice for travelers in these areas in the Travel Advisory. Conditions in any country may change at any time.

4. RESPONSIBILITIES

4.1 The SVP, Director EHS and Quality and the Director, Corporate Safety and Compliance is responsible for the following:

- Implement this Program throughout TRC.
- Define roles and responsibilities necessary to effectively implement this Program.
- Facilitate communications to employees and management during pandemic events.
- Periodically review the effectiveness of this Program and modify as necessary to ensure it remains current and effective.

4.2 Office Safety Coordinators are responsible for the following:

- Communicate the requirements of this Program to office personnel.
- Work with Office Managers to verify hand-hygiene products are available in the office and appropriate office sanitizing methods are practiced.

4.3 Project Managers and Supervisors are responsible for the following:

- Consult with the SVP, Director EHS and Quality and Director, Corporate Safety and Compliance, and monitor travel advisories for the geographic areas where employees are either working at or will be traveling to soon.
- Assist with implementing the health and travel precautions recommended by the respective authorities and TRC.
- Notify clients of project delays due to travel restrictions.
- Communicate and support mitigation strategies to employees.

4.4 Employees are responsible for the following:

- Follow health and travel precautions in accordance with this Program and guidance provided by TRC leadership.
- Review health and travel advisories issued by the government and health organizations prior to travelling outside the United States or to locations within the United States that may be considered at risk.
- Provide feedback on the effectiveness of this Program to Project Managers/Supervisors and Office Safety Coordinators to improve the effectiveness of this Program.

5. PROCEDURES

5.1 Risk Assessment

- A pandemic disease presents a serious health risk and could prevent TRC from serving clients. The risk to employee health and the business will vary based on the geographic area of the pandemic and the potential severity of the disease.
- The SVP, Director EHS and Quality and/or the Director of Corporate Safety and Compliance will facilitate the risk assessment in consultation with members of the executive team and the Crisis Management Committee to assess the potential impact of a pandemic on domestic and international business and associated travel (e.g. quarantines, border closures, etc.).
- The risk assessment will consider governmental agencies, including the Center for Disease Control (CDC), World Health Organization (WHO), and the US Department of State, for up-to-date pandemic information. Community public health, emergency management, and other sources will also be monitored.
- Additionally, the risk assessment will need to identify the essential/critical components of our business operation that need to be conducted during the pandemic.
- Based on this evaluation, mitigation strategies outlined in this Program will be implemented to protect employees and minimize interruption to TRC's business.

5.2 Communication

- Provide Periodic updates through internal & external communications when a pandemic is imminent:
  - Notification to employees of operational changes.
  - Provide frequent updates about the pandemic status.
  - Provide advisories and alerts as conditions change.
  - Monitor local, state, and federal pandemic updates.
- Internal Communication
  - Internal communication will be provided to employees to educate them about pandemic diseases and measures they can take to be prepared.
  - Health and travel information will be closely monitored by the Crisis Management Committee. Necessary mitigation strategies and pandemic status will be routinely provided to employees through regular business communications which may include e-mail, Safety Alerts, electronic mass communication systems (i.e., Honeywell/Everbridge), telephone, etc.
- External Communication
  - Project Managers will keep clients informed of project schedules and potential delays due to travel advisories and impacts to supply chains.

5.3 Pandemic Response by Pandemic Phase

- Currently the World Health Organization (WHO) has created various phases for a pandemic.
  - **Phase 1:** No viruses circulating among animals have been reported to cause infections in humans.
  - **Phase 2:** An animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans and is therefore considered a potential pandemic threat.
  - **Phase 3:** An animal or human-animal influenza reassortment virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for example, when there is close contact between an infected person and an unprotected caregiver. However, limited transmission under such restricted circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.

- **Phase 4:** Characterized by verified human-to-human transmission of an animal or human-animal influenza reassortment virus able to cause "community-level outbreaks." The ability to cause sustained disease outbreaks in a community marks a significant upwards shift in the risk for a pandemic. Any country that suspects or has verified such an event should urgently consult with WHO so that the situation can be jointly assessed, and a decision made by the affected country if implementation of a rapid pandemic containment operation is warranted. Phase 4 indicates a significant increase in risk of a pandemic but does not necessarily mean that a pandemic is a forgone conclusion.
- **Phase 5:** Characterized by human-to-human spread of the virus into at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.
- **Phase 6:** This pandemic phase, is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.
- During the post-peak period, pandemic disease levels in most countries with adequate surveillance will have dropped below peak observed levels. The post-peak period signifies that pandemic activity appears to be decreasing; however, it is uncertain if additional waves will occur and countries will need to be prepared for a second wave.
- In the post-pandemic period, influenza disease activity will have returned to levels normally seen for seasonal influenza. It is expected that the pandemic virus will behave as a seasonal influenza virus. At this stage, it is important to maintain surveillance and update pandemic preparedness and response plans accordingly. An intensive phase of recovery and evaluation may be required.

5.4 Mitigation Strategies

TRC will follow health and travel precautions issued by the respective authorities. One or more of the following precautions may be implemented based on business condition and guidance from authorities.

5.4.1 Telecommute:

- Many TRC employees have the ability to telecommute. Employees are encouraged to stay at home when ill, when having to care for ill family members, or when caring for children due to school closure. TRC also offers Personal Time Off (PTO) as an option for employees.
- Employees should stay at home when sick or otherwise experience symptoms that are consistent with the pandemic disease.

5.4.2 Infection Control Measures:

Infection control is an essential component of pandemic management and a component of public health measures. Essential measures include:

- Practice frequent hand washing. According to the CDC, washing hands with soap and water is the best way to get rid of germs in most situations. If soap and water are not readily available, you can use an alcohol-based hand sanitizer that contains at least 60% alcohol. You can tell if the sanitizer contains at least 60% alcohol by looking at the product label.
- Obtain immunizations recommended by healthcare providers to help avoid disease.
- Practice social distancing to increase the space between employee work areas and decreasing the possibility of contact by limiting large or close contact gatherings and avoid shaking hands.
- Frequently disinfect all areas that are likely to have frequent hand contact (like doorknobs, faucets, handrails).

5.5 Travel

Prior to traveling outside the United States, employees and project managers should review the current travel advisory levels that are posted on the United States Department of State. These advisories provide safety and security information intended for US travelers who are intending to travel outside the United Sates. The travel advisory system includes the following levels:

- **Level 1 – Exercise Normal Precautions**
- **Level 2 – Exercise Increased Caution**
- **Level 3 – Reconsider Travel**
- **Level 4 – Do Not Travel**

TRC's Crisis Management Committee will periodically monitor travel advisory levels and will provide company guidance on business travel to areas with active travel advisories.

6. TRAINING

TRC has a Pandemic Flu Preparedness course available to employees through the TRC Academy. Employees may complete this course if they want further information on illness prevention and avoiding the spread of disease. This course discusses disease containment strategies and disease prevention.

7. EVALUATION

The plan and emergency communication strategies will be periodically reviewed to ensure it remains current and effective. Performance of this plan during actual events will be considered for continual improvement.

8. REFERENCES/RELATED DOCUMENTATION

CP048 TRC Business Continuity Plan

CP053 Crisis Management Committee Program

9. APPENDICIES

A CP052.1 Field Guidelines COVID-19

10. REVISION HISTORY

Revision Number	Revision Date	Summary of Revision	Modified by
0	5/3/10	New Document	Gary Ritter
1	6/23/15	Minor Revisions to previous program	Mike Glenn
2	3/3/20	Updated to reflect COVID-19 and included as part of the HSMS	Mike Glenn and Todd Woletz
3	3/17/20	Added COVID-19 Field Guidelines	Tim Johnson

Attachment A
CP052.1 Field Guidelines COVID-19

STEPS TO FOLLOW IF YOU DEVELOP SYMPTOMS

Symptoms and Warning Signs	Take the following steps
If you experience the following **symptoms**, which may appear **2-14 days after exposure.** • **Fever** • **Cough** • **Shortness of breath**	1. Notify your field and direct supervisor that you feel ill. 2. Immediately isolate yourself and return to your place of lodging (return home if nearby). 3. Contact your personal healthcare provider asap (consider using the Cigna app) for evaluation and follow their instructions. 4. Update your field and direct supervisor of your health and work status (e.g., when do you expect to return to work). 5. If you're diagnosed with COVID-19 notify Mike Glenn (949-697-7418) and your HR Business Partner immediately. This communication will be treated as confidential.
If you develop any of the following **emergency warning signs:** • Difficulty breathing or shortness of breath, • Persistent pain or pressure in the chest, • New confusion or inability to arouse, • Bluish lips or face This list is not all inclusive so please consult with your medical provider for further guidance.	1. Get medical attention immediately. 2. If you're diagnosed with COVID-19, notify Mike Glenn (949-697-7418) and your HR Business Partner immediately. This communication will be treated as confidential.

Source: CDC COVID-19 Symptoms https://www.cdc.gov/coronavirus/2019-ncov/about/symptoms.html

PRECAUTIONS

1. Practice Social Distancing

   Avoid "close contact" which is either 1) a "prolonged period of time" spent "within approximately 6 feet or within the room or care area" of an individual who has been positively diagnosed with the virus or 2) "direct contact with infectious secretions."
   Do not share eating or drinking utensils, avoid close conversation, and other direct physical contact like hand shaking. "Close contact" does not include activities such as walking by a person or briefly sitting across an office.

2. Hand Hygiene

   According to the CDC, washing hands with soap and water is the best way to get rid of germs in most situations. If soap and water are not readily available, you can use an alcohol-based hand sanitizer that contains at least 60% alcohol. You can tell if the sanitizer contains at least 60% alcohol by looking at the product label.

3. Practice good respiratory hygiene – covering mouth and nose when coughing or sneezing, using tissues and disposing of them correctly.
4. Obtain immunizations recommended by healthcare providers to help avoid disease.
5. Early self-isolation of those feeling unwell, feverish and having other symptoms of flu.
6. Avoiding touching your eyes, nose or mouth.
7. Frequently disinfect all areas that are likely to have frequent hand contact (like doorknobs, faucets, handrails).

CLIENT MEETINGS/INTERACTIONS

Be aware of any restrictions or requirements that clients have in place regarding visiting client facilities or attending meetings. Verify with supervisor/project managers prior to visiting client facilities or meetings in person.

BACKGROUND

The 2019 novel coronavirus, or COVID-19, is a new respiratory virus first identified in Wuhan, Hubei Province, China. It's called a "novel" — or new — coronavirus, because it is a coronavirus that has not been previously identified.

Both the COVID-19 and influenza (flu) are respiratory illnesses, which have similar symptoms. Both are contagious and both can be mild or severe, even fatal in rare cases. The key difference between the novel coronavirus and influenza is we know what to expect from the flu.

SYMPTOMS OF COVID-19

Initial symptoms of COVID-19 usually include fever greater than 100.4°F (38.0°C), cough, and shortness of breath. However, not all affected individuals will exhibit all symptoms. If you experience these symptoms or have been in recent close contact with someone with these symptoms, notify your doctor and stay home.

TRANSMISSION

Both COVID-19 and the flu can be spread from person to person through droplets caused by an infected person coughing, sneezing or talking. Flu can be spread by an infected person for several days before their symptoms appear, and COVID-19 is believed to be spread in the same manner, but we don't yet know for sure.

Title: **Equipment Decontamination**	Procedure Number: **ECR 010**
	Revision Number: **1**
	Effective Date: **December 2016**

Authorization Signatures

Technical Reviewer Date James Peronto 12/15/16	ECR Practice Quality Coordinator Date Elizabeth Denly 12/15/16

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the procedures needed for decontamination of equipment used in the field during environmental investigations (e.g., sediment, soil, groundwater investigations). Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination.

The use of dedicated, disposable, new sampling equipment (e.g., disposable liners, plastic spoons, plastic or aluminum bowls) should be considered as an alternative to equipment decontamination and the subsequent generation of decontamination fluids.

1.2 Summary of Method

Equipment decontamination is used to remove potential contaminants from a sampling device or piece of field equipment prior to and between the collection of samples and is also used to limit personnel exposure to residual contamination that may be present on used field equipment.

Contaminants can be physically removed from equipment or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and nonabrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water, followed by a wash/rinse process using appropriate cleaning solutions. A solvent rinse may be required when organic contamination is present, and an acid rinse may be required when metals are parameters of interest. Equipment decontamination procedures can vary depending on the media being sampled and the type of sampling equipment being used. Disposal of decontamination fluids will be handled on a project-specific basis and will be in accordance with all applicable regulations.

1.3 Equipment

The following equipment may be utilized when decontaminating equipment. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment B for further details.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)

- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate (may be supplied by the laboratory or purchased from commercial vendors depending on project requirements)
- Pump sprayer
- Pressure sprayer
- Squeeze bottle filled with pesticide-grade hexane (option for organic analyses)
- Squeeze bottle filled with pesticide-grade methanol (option for organic analyses)
- Squeeze bottle filled with pesticide-grade isopropanol (option for organic analyses)
- Squeeze bottle filled with 10 percent nitric acid (option for metals analyses and stainless-steel equipment)
- Squeeze bottle filled with 1 percent nitric acid (option for metals analyses)
- Container (squeeze bottle to 5-gallon bucket) filled with potable water and a nonphosphate, laboratory-grade soap (approximately 1 tablespoon of soap to 5 gallons of water)
- Extra quantities of above listed liquids
- Potable water
- Containers, such as buckets or wash basins (the type and number of containers is dependent on the procedure)
- Scrub brushes
- Small wire brush
- Aluminum foil
- Polyethylene sheeting
- A container for decontamination of pumps and associated tubing.

1.4 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Samples containing chemical contaminants may be handled during implementation of this SOP. Certain decontamination fluids, including solvents and/or acids, are considered hazardous materials, and TRC employees will appropriately handle and store them at all times. Appropriately manage chemicals that pose specific toxicity or safety concerns, and follow any other relevant requirements as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Some hazardous substances may be incompatible with clothing or equipment and can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through

inhalation or skin contact or if exposed to heat/flame and they combust. Safety data sheets for chemicals handled by TRC personnel should be maintained in a designated location at the project site.

1.5 Cautions and Potential Problems

Special care should be taken when decontaminating equipment used for sampling for PFAS. Please refer to Attachment B for details.

- The use of deionized, distilled or organic-free water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been certified by the vendor as analyte-free and/or meets the project-specific requirements.

- Alconox®, Liquinox®, or other nonphosphate, concentrated, laboratory-grade soap may contain trace quantities of perchlorate.

- Avoid using an excessive amount of soap during decontamination procedures, as this could result in difficulty rinsing the soap residue off of the equipment. Typically the soap solution is prepared using 1 tablespoon of soap to 5 gallons of water.

- Use sufficient amount of decontamination fluid (e.g., acid or solvent rinses) so that the fluid flows over the equipment and runs off. Spraying the equipment with a minimal amount of decontamination fluid that does not run off is ineffective.

- Spent decontamination solutions are considered investigation-derived waste (IDW) and must be managed as directed by the site-specific field program. Project and regulatory requirements, chemical compatibility, ambient conditions and professional judgment should be used to determine the appropriate decontamination process with respect to combining and/or segregating decontamination fluids. Section 3 of this SOP provides more guidance on the disposal procedures.

- Several procedures can be established to minimize the potential for cross-contamination or analytical interference by decontamination fluids. For example:

  - The use of methanol in the decontamination procedure may not be appropriate if methanol is a contaminant of concern.

  - Isopropanol may be used as a substitute for methanol but may not be appropriate when collecting samples for volatile organic compound (VOC) analyses. Residual isopropanol on the equipment may cause substantial interferences in subsequent VOC analyses and may result in unnecessary dilutions and/or false positive results if isopropanol is not removed in subsequent decontamination steps. It should also be noted that the application of isopropanol to hot metal surfaces (e.g., a steam-cleaned split spoon) may cause oxidation of the isopropanol to acetone.

- If hexane is used in the decontamination procedure, caution should be used to ensure that the hexane is completely volatilized and the equipment is subsequently rinsed when samples are to be analyzed for VOCs and volatile petroleum hydrocarbons (VPH). Residual hexane on equipment could interfere with the VOC and VPH analyses and may result in unnecessary dilutions and/or false positive results.

- Cover monitoring and sampling equipment with protective material (i.e., aluminum foil, polyethylene sheeting, or Ziploc® bags) to minimize potential re-contamination after decontamination.

- Use disposable sampling equipment when appropriate to minimize the need for decontamination. Although disposable sampling tools are encouraged in order to minimize the generation of decontamination fluids, it should be noted that plastic tools may not be appropriate for collection of samples to be analyzed for semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Potential phthalate contamination may cause significant interferences in the subsequent analyses and may result in unnecessary dilutions and/or false positive results.

- After decontamination, equipment should be handled only by personnel wearing clean disposable powder-free nitrile gloves to prevent recontamination.
- If equipment decontamination is performed in the field, the equipment should be moved away (preferably upwind) from the decontamination area to prevent recontamination.
- Equipment that is not decontaminated properly may result in potentially high biased results in field samples. **Note:** Equipment blank collection may be appropriate after decontamination of equipment used to collect highly contaminated samples.

1.6 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the site-specific sampling plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes.

2.1 General

All personnel, sample containers, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants by abrasive and/or washing actions, inactivate contaminants by disinfection or sterilization, or both. Decontamination procedures should be documented in the field book.

2.2 Physical Decontamination Procedures

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and nonabrasive methods. In general, heavy equipment decontamination is conducted by drilling and construction subcontractors and not by TRC personnel. However, TRC personnel will typically need to document such decontamination efforts as part of project work.

ABRASIVE CLEANING METHODS APPROPRIATE FOR DRILLING EQUIPMENT (DRILLING RIGS, ETC.)

Abrasive cleaning methods involve rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available but are not commonly used:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- *Air Blasting:* Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs, or auger bits. The equipment used in air blasting employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive material strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages, including it is unable to control the amount of materials removed, it can aerate contaminants, and it generates large amounts of waste.

- *Wet Blasting:* Wet blasting, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. One disadvantage of this method is the generation of a large amount of waste.

NONABRASIVE CLEANING METHODS APPROPRIATE FOR FIELD EQUIPMENT (DRILLING AUGERS AND RIGS, ETC.)

Nonabrasive cleaning methods involve forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using nonabrasive methods. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. The following non-abrasive methods are available:

- *High-pressure Potable Water:* This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high-pressure hose. Flow rates typically range from 20 to 140 liters per minute.

  This procedure is used the majority of the time and is more appropriate for equipment with painted surfaces.

- *Ultrahigh-Pressure Potable Water:* This system produces a pressurized water jet. The ultrahigh-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 meters per second (m/sec) to 900 m/sec. Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

  This procedure is not commonly used but would be appropriate for carbon steel drilling rods and augers.

2.3 Procedure for Sampling Equipment

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. **Note:** The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. The number of decontamination steps and designated containers should be determined prior to field sampling based on the site-specific sampling plan. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. If more than one, the nonwater rinsate fluids may need to be separated. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. Place the containers on the polyethylene sheeting. The decontamination line should progress from "dirty" to "clean".

   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.

2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container. Do not use an excessive amount of the soap (approximately 1 tablespoon of soap to 5 gallons of water), or rinsing the soap residue off of the equipment will be difficult.

3. Brush any visible dirt off of the sampling equipment into a designated area before getting equipment wet.

4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container, removing all dirt or visible hydrocarbons. Allow excess soap to drain off the equipment into the container when finished. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

5. Rinse the equipment with potable water over an appropriate container, using a coarse scrub brush or pressure sprayer to aid in the rinse if necessary. If an additional acid or solvent rinse is not required, proceed to Step 8.

6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.

   Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Cautions and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.

   Allow the equipment to completely air dry prior to proceeding to the next step.

   **** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.**

8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container) (See*NOTE).

   ***NOTE** that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water

should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field book or on the appropriate form.

10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.

11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

12. Record the decontamination procedure in the field book or on the appropriate form.

2.4 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers, water level indicators, oil/water interface probes, and soil moisture/pH meters will be cleaned using the following procedure, unless it conflicts with the manufacturer's recommendations. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details.

1. Fill two clean containers (e.g., plastic wash basins or buckets) with potable water.

2. Add sufficient nonphosphate concentrated laboratory-grade soap to one container to form a thin layer of soap suds. If oily residues are apparent, the use of Simple Green® may be required.

3. Brush any visible dirt off of the measuring equipment before getting the equipment wet.

4. Either spray rinse the device with the soap solution over the first container, or for heavily soiled equipment, immerse the device in the container containing soap and gently agitate. Scrub device if it is soiled. Do not submerse any electrical controls or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

5. Immerse the device in the container containing the potable water and gently agitate. Do not submerse any electrical connectors or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

6. Spray rinse equipment with deionized, distilled, or organic-free water over the last container used.

7. Allow the equipment to air dry if time allows.

8. Record the decontamination procedure in the field book or on the appropriate form.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for IDW disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the equipment blank. The equipment blank provides information about the effectiveness of the decontamination process employed in the field. An equipment blank can detect contamination that may arise from potentially contaminated equipment or equipment that has not been decontaminated effectively.

Equipment blanks consist of a sample of analyte-free (i.e., deionized, distilled, organic-free) water that is poured over and through a decontaminated sampling device and placed in a clean sample container. Ideally, the reagent water should come from the laboratory and be certified as clean. If the blank water is not certified as clean and/or not supplied by the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should also be sent to the laboratory for analysis.

Equipment blanks are typically collected for all parameters of interest at a minimum rate of 1 per 20 samples for each parameter. The frequency of equipment blank collection will vary from project to project, depending upon the data quality objectives, and will be specified in either the site-specific sampling plan or QAPP. Equipment blanks are typically not required if dedicated sampling equipment is used.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or on the appropriate form. Any deviations from the decontamination procedures specified in the sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field book. Refer to RMD SOP 001 for field documentation procedures.

6.0 REFERENCES

USEPA. December 1987. *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001.

USEPA. January 1991. *Compendium of ERT Groundwater Sampling Procedures*. OSWER Directive 9360.4-06. PB91-9211275.

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. January 1999. *Compendium of ERT Groundwater Sampling Procedures*. EPA/540/P-91/007. OSWER Directive 9360.4-06. PB91-921275.

USEPA. December 20, 2011. *Field Equipment Cleaning and Decontamination*. SESDPROC-205-R2. Region 4. Science and Ecosystems Support Division. Athens, Georgia.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
1	DECEMBER 2016	ADDED ATTACHMENT B TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

Attachment A: SOP Fact Sheet

EQUIPMENT DECONTAMINATION

Purpose and Objective

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

What to Bring

- Field book
- Appropriate PPE
- Site-specific HASP
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate
- Potable water (or water containers if potable water source on site or nearby)
- Pump or pressure sprayer
- Squeeze bottles filled with appropriate decontamination chemicals (e.g., organic solvents, nitric acid)
- Containers, such as buckets or wash basins (type and number is dependent on the procedure)
- Scrub brushes
- Aluminum foil
- Polyethylene sheeting

Office

- Prepare/update the site-specific HASP; make sure the field team is familiar with the latest version.
- Review site-specific sampling plan/QAPP for decontamination procedures and procedures for management of investigation-derived waste (IDW) (e.g., used decontamination solutions).
- Confirm all required decontamination supplies are in stock or order as needed.

On-Site

- Verify project HASP including safety data sheets for decontamination chemicals used on site.
- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Establish a designated equipment and personnel decontamination area.
- Provide for the proper collection and management of all IDW.
- Verify that appropriate PPE is worn by all site personnel (including subcontractors) and the work area is safe.

Sampling Equipment Decontamination - Procedures

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. **A more simplified procedure for decontamination of measuring equipment is presented in the SOP.** Note: The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor and the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. The decontamination line should progress from "dirty" to "clean".
   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.
2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container.
3. Brush any visible dirt off of the sampling equipment before getting equipment wet.
4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container.

EQUIPMENT DECONTAMINATION

5. Rinse the equipment with potable water over an appropriate container. If an additional acid or solvent rinse is not required, proceed to Step 8.
6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.
7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Caution and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.
   Allow the equipment to completely air dry prior to proceeding to the next step.
   ** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.
8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water.
9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container).
   *NOTE that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field logbook or on the appropriate form.
10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.
11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

INVESTIGATION DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or an appropriate field form. Any deviations from the decontamination procedures specified in the work plan, sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field logbook. Refer to RMD SOP 001 for field documentation procedures.

DOs AND DO NOTs OF EQUIPMENT DECONTAMINATION

DOs:

- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them on site work.
- DO manage and collect IDW in accordance with project requirements.
- DO use deionized, distilled or analyte free water that is provided by the laboratory, is certified analyte-free, and/or meets project requirements.
- DO use sufficient amount of decontamination fluids so that the fluid flows over the equipment and runs off.
- DO use new wrapped disposable dedicated sampling equipment when appropriate to minimize the need for decontamination.

DO NOTs:

- DO NOT use an excessive amount of soap during decontamination.
- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc.; call PM if this issue arises.

Attachment B: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

<table>
<tr><th colspan="2">PFAS Equipment Decontamination Protocols</th></tr>
<tr><th>SOP Section Number</th><th>Modifications to SOP</th></tr>
<tr><td>1.3</td><td>• Use only Alconox® or Liquinox® soap; do not use Decon 90.
• Use new plastic buckets for wash and rinse water.
• Ensure that PFAS-free water is used during the decontamination procedure.
• Do not use aluminum foil.</td></tr>
<tr><td>1.5</td><td>Always consult the Site-specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to decontamination procedures:
• Tyvek® suits should not be worn. Cotton coveralls may be worn.
• Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable.
• Food and drink should not be allowed within the decontamination area. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only.
• Personnel involved with decontamination should wear a new pair of nitrile gloves after each decontamination procedure when handling equipment to avoid re-contamination. Avoid handling unnecessary items with nitrile gloves.
• Do not store on or cover equipment with aluminum foil after decontamination. Use of polyethylene sheeting is acceptable.
• Avoid wearing clothing laundered with fabric softeners.
• Avoid wearing new clothing (recommended six washings since purchase). Clothing made of cotton is preferred.
• Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work.</td></tr>
<tr><td>2.2</td><td>• New nylon or metal bristle brushes should be used for mechanical cleaning methods.
• If high-pressure water is used, it must be tested prior to use for presence of PFAS.</td></tr>
<tr><td>2.3</td><td>• Ensure that PFAS-free water is used during the decontamination procedure.</td></tr>
<tr><td>2.4</td><td>• Ensure that PFAS-free water is used during the decontamination procedure.</td></tr>
</table>

1. PURPOSE

The purpose of this Personal Protective Equipment (PPE) Program is to explain the responsibilities and procedures for identifying and providing the proper PPE to protect employees from known or potential workplace hazards.

2. SCOPE

This program applies to all TRC employees who are exposed to physical or health hazards.

3. DEFINITIONS

ANSI: American National Standards Institute

Face Shield: Face Protection that meets ANSI Z87.1-1989 requirements. They provide a physical barrier around the face/neck area and are worn in addition to safety glasses or safety goggles depending on the task.

Hard Hats: Head coverings which meet ANSI Z89.1-2009 requirements.

Personal Protective Equipment (PPE): Includes all clothing and other work accessories designed to create a barrier against workplace hazards. Examples include safety goggles, hard hats, hearing protectors, gloves, respirators, aprons, and work boots.

Safety Glasses: Eye glasses that meet ANSI Z87.1-1989 requirements which details minimal eye protection against foreign bodies entering the eye. Safety glasses have impact and heat resistance lenses and permanently affixed side shields.

Safety Goggles: Eye encapsulating goggles which meet ANSI Z87.1-1989 requirements. Safety goggles provide a tightly sealed physical barrier around the entire eye area.

Safety Shoes: Shoes which meet American Society for Testing and Materials (ASTM) standard F2413-05.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for overall implementation and maintenance of this program.

4.2 The Health and Safety Network is responsible for program implementation including, but not limited to:

- Develop the standard for PPE that will be used on-site through the site-specific Health and Safety Program.
- Potentially serve as the Competent Person for implementation of the PPE Program.
- Train new and existing TRC project employees (see CP009 – Health and Safety Training Program).
- Communicate and coordinate TRC's PPE requirements with all TRC subcontractors.

- Oversee and coordinate TRC and other project employees with implementing site-specific Task Safety and Environmental Assessments to identify the hazards and control measures (including PPE) associated with work scheduled for that day. (See *Job Safety Analysis (JSA) Program*).
- Review and approve all TRC and subcontractor PPE utilization.
- Perform program audits and inspections in conjunction with on-site TRC subcontractor, and site Health and Safety representatives or their designees.
- The Health and Safety Network will provide non-prescription safety eyewear when deemed necessary.
- Maintain records for Health and Safety activities on-site including equipment inspections and procedural audits of employee PPE implementation (see Audits and Inspections and Documentation).

4.3 The Health and Safety Network is responsible for establishing appropriate PPE levels and providing PPE to TRC employees. Subcontractors will determine who will serve as their Competent Person and provide the required level of PPE for their employees. The Competent Person will also:

- Assist the Health and Safety Network in reviewing and approving all TRC and Subcontractor PPE utilization developed for the site (see CP002 - Risk Analysis/Site-Specific Health and Safety Program).
- Perform program audits and inspections in conjunction with on-site TRC subcontractor, and on-site Health and Safety representatives or their designees.

4.4 Site employees are accountable for performing work in a safe manner according to the requirements of the PPE Program. All TRC and other project employees working on-site will be required to participate in training and daily development and review of work-specific JSAs to identify the hazards and control measures (including PPE) associated with work scheduled for that day. Employees found in willful violation of safety policies will risk disciplinary action up to and including termination as outlined in Employee Handbook. Site employees are also responsible for the selection and use of their PPE and for wearing and utilizing the assigned PPE, in a proper manner.

4.5 Project Managers are responsible for assisting the Health and Safety Network in the implementation of the PPE Program. Project Managers hold all TRC and other project employees working on-site accountable for maintaining a safe work environment.

4.6 Contractors are required to follow the provisions of this program by participating in the work risk assessment which defines the risks and the associated PPE for mitigation.

5. PROCEDURES

5.1 General Requirements:

5.1.1 PPE includes different types of protective equipment and clothing, such as gloves, safety glasses/goggles, safety shoes and boots, shoe/boot covers, hardhats, coveralls, and respirators.

5.1.2 In general, the following PPE is the minimum required on all TRC project sites:

- ANSI-rated hardhats (may require chin straps when climbing structures).
- ANSI-rated safety glasses with side shields.
- ANSI-rated steel- or safety-toed boots which, at a minimum, cover the ankle.
- ANSI-rated, high-visibility reflective vest or outerwear.

5.1.3 PPE will be provided, used, and maintained in a sanitary and reliable condition. At no time will defective or damaged PPE be used by TRC employees. TRC will provide initial and replacement PPE to its affected employees at no cost to the employee.

5.2 Hazard Assessment and Risk Management:

5.2.1 TRC's Risk Analysis/Site-Specific Health and Safety Program is used as a method for selecting the appropriate PPE for known and potential hazards. The JSA is developed from identified Health and Safety hazards in the hazard assessment for the site, and risk analysis at the job level.

5.3 Basic PPE Requirements:

5.3.1 Hardhats – Required by all employees working at project sites that have overhead hazards (including contact with electrical equipment), except when inside administrative office areas. Hardhats subjected to an impact due to a falling object must be inspected for damage prior to re-use. Damaged hardhats will be taken out of service and a replacement provided by the Health and Safety Network.

5.3.2 Safety Glasses/Goggles/Face Shield – Safety glasses are required by employees working at sites that have potential eye hazards such as flying particles, chemical splash, or compressed air. Face shields provide additional protection for the eyes and face when used with safety glasses or goggles; however, face shields may not be used in lieu of safety glasses. Face shields are required for grindings operations.

- Goggles, or a face shield over side shield safety glasses are required to be worn whenever working in operations or areas that present increased risk of eye injury or face injury such as: handling corrosive or irritating chemicals or grinding.
- During hot work operations, employees shall wear safety glasses with No. 5 or darker lens and a face shield.

5.3.3 Protective Footwear - Employees are required to wear steel- or safety-toe, cut and slip resistant boots with a defined, notched heel (not greater than 2") which extends high enough to cover the employee's ankle.

5.3.4 Hearing protection - Ear muffs and/or ear plugs shall be worn by employees who are exposed to noise levels that exceed an 8-hour time weighted average of 85 dBA or higher.

Noise Reduction Rating (NRR) Derating – Manufacturers offer the NRR as tested for their PPE. This number is not "as used" NRR, meaning it is not tested in actual work conditions. Therefore, the National Institute of Safety and Health (NIOSH) recommends that the labeled NRRS be derated as follows:

- For example, measure noise exposure levels in dBA with a sound level meter or noise dosimeter, the effective A-weighted Exposed Noise Level (ENL) is :

ENL = dBA – (derated NRR-7).

5.3.5 Gloves - Gloves protect hands from injury due to abrasive surfaces, heat, or contact with chemical substances that can cause chemical burns or skin absorption. The selection and use of gloves for protection against physical, chemical, and/or biological hazards are based on the following criteria:

- Laceration – Employees involved in tasks that could potentially expose them to laceration hazards should wear cut resistant gloves.
- Chemical – Employees involved in tasks that have been identified as chemical hazards shall be protected through the use of chemical-resistant gloves.
- Biological – Employees involved in tasks that have been identified as having microorganism hazards shall be protected through the use of latex gloves. Occupational Safety and Health Administration (OSHA) Bloodborne Pathogens final rule mandates wearing gloves in specified circumstances to reduce the risk of exposure to bloodborne pathogens. In addition, the following procedures from the Centers for Disease Control and Prevention (CDC) shall be utilized:
  - Wash hands thoroughly and promptly after contact with blood, body fluids, secretions, excretions, equipment, and potentially contaminated articles. Wearing gloves does not replace the need for hand washing. Gloves may have small, non-apparent defects or may be torn during use, and hands can become contaminated during removal of gloves. Gloves must be changed between contacts, and hands should be washed after gloves are removed.

5.3.6 Respirators – Respirators are to be selected, used and maintained in accordance with TRC's Respiratory Protection Program.

5.3.7 Fall Protection Equipment – Personal fall arrest devices must be worn by employees who are exposed to fall hazards greater than 4 feet, and also when standing inside elevating work platforms (i.e., articulating boom lit). Refer to TRC's Fall Protection Program for details pertaining to types of equipment and situations for their use.

5.3.8 Flame Resistant Clothing (FRC) – FRC shall be provided and worn when required by site owner or when the work risk assessment process determines the need for additional protection due to exposure to hazards such as flammable/combustible liquids, arc flash, or molten metal. FRC should be worn as the outer-most garment. FRC garments shall comply with the following requirements:

- Fabric Weight – FRC materials shall not weigh less than 4 oz/yd2 (150 g/m2).
- FRC materials shall comply with National Fire protection Association (NFPS) 2112 Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire and tested to ASTM F1930, standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulation Using an Instrumented Manikin.
- Optional reflective stripes shall conform to the International Safety Equipment Association (ISEA) 107, Level 2, American National Standard for High Visibility Safety Products and Headwear.

5.3.9 PFDs – Personal floatation devices are to be used when working over or near water. They should be US Coast Guard approved Type I, II, III or V PFDs. They should be fitted with a safety of Life At Sea convention compliant whistle or noise-making device. When worn at night, PFDs should have Safety of Life at Sea rated reflective tape or materials affixed to the PFD.

5.4 Training:

5.4.1 All TRC and other project employees will receive training during Site-Specific Orientation regarding TRC's requirements involving the hazards associated with all work. In addition, all employees will be trained regarding how PPE usage correlates with their work duties.

5.4.2 Before performing work requiring the use of selected PPE, each affected TRC employee will be trained to understand at a minimum the following:

- When PPE is necessary.
- What PPE is necessary.
- How to properly don, doff, adjust, and wear PPE.
- The limitations of the PPE.
- The proper care, maintenance, useful life, and disposal of the PPE.

5.4.3 Retraining of an employee is required when changes make previous training obsolete; changes in types of PPE occur; or when the employee demonstrates lack of use, improper use, or insufficient skill or understanding of PPE.

5.4.4 Employees who are required to wear fall protection or respiratory protection shall receive site-specific training above and beyond the general site-specific orientation. This training will be provided or coordinated by the Health and Safety Network.

5.5 Audits and Inspections:

5.5.1 Inspections/audits of PPE utilization, and compliance with established guideline can be conducted by the Health and Safety Network, listed Competent Person(s), or the client's representative. Inspections/audits shall be documented in the project files and deficiencies shall have timely corrective action measures defined. The auditor will be responsible for ensuring that corrective measures are met within the established timeframe, and must report any non-compliance to the Project Manager for immediate follow up.

5.5.2 All PPE shall be visually inspected daily by the user prior to use. This inspection is not required to be documented; however, potential defects in PPE shall be brought to the Competent Person's attention, and the equipment shall be removed from service until it can be determined if it is safe to use. Unsafe equipment will be removed from service, destroyed, and replacement equipment will be provided to the employee.

5.6 Documentation:

5.6.1 Records of training, audits, and inspections associated with project work shall be maintained by the Health and Safety Network in the project file on-site throughout the life of the contract, and transmitted to the project files for storage when the work has been completed.

5.6.2 Training records for non-project work will be maintained by the Office Safety Coordinators and TRC's Training Coordinator.

5.6.3 Records of non-compliance (personal and company) shall be maintained in the associated employee's or Subcontractor's files for the duration of the project.

6. REFERENCES/RELATED DOCUMENTATION

29 CFR 1910.132 – OSHA PPE Standard

CP002 – Risk Analysis/Site-Specific Health and Safety Program

1. PURPOSE

TRC provides appropriate respirators to employees when necessary to protect them from over-exposure to airborne contaminants. When effective engineering controls are not feasible to prevent over exposure to harmful air contaminants, respirators shall be used in accordance with this program. This Respiratory Protection Program establishes procedures for respirator selection, use, care, maintenance, and storage.

2. SCOPE

This procedure applies to all TRC employees required to wear a respirator.

3. DEFINITIONS

Air-Purifying Respirator: a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

Atmosphere-Supplying Respirator: a respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and includes Supplied-Air Respirators (SARs) and Self-Contained Breathing Apparatus (SCBA) units.

Canister or Cartridge: a container with a filter, sorbent, or catalyst, or combination of these items, which removes specific contaminants from the air passed through the container.

Demand Respirator: an atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.

End-of-Service-Life Indicator (ESLI): a system that warns the respirator user of the approach of the end of adequate respiratory protection (for example, that the sorbent is approaching saturation or is no longer effective).

Fit Factor: a quantitative estimate of the fit of a particular respirator to a specific individual; typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

Fit Test: the use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual.

HASP: Health and Safety Plan.

High Efficiency Particulate Air (HEPA) Filter: a filter that is at least 99.97 percent efficient in removing monodisperse particles of 0.3 micrometers in diameter.

Immediately Dangerous to Life or Health (IDLH): an atmosphere that poses an immediate threat to life and/or has the potential to cause irreversible adverse health effects or impair an individual's ability to escape from a dangerous atmosphere.

Negative Pressure Respirator (tight-fitting): a respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator.

OSC: Office Safety Coordinator.

Positive Pressure Respirator: a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

Powered Air-Purifying Respirator: an air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

Qualitative Fit Test (QLFT): a pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

Quantitative Fit Test (QNFT): an assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

Service Life: the period of time that a respirator, filter or sorbent, or other respiratory equipment provides adequate protection to the wearer.

4. RESPONSIBILITIES

4.1 The National Safety Director administers the respiratory program for TRC.

4.2 The evaluation of the overall Respiratory Protection Program is the responsibility of the National Safety Director.

4.3 The Project Manager, with support from the Safety Department, is responsible for assessing the risks of a project including identification of when respiratory protection may be required.

4.4 The Human Resources Department is responsible for coordinating medical evaluations for employees who are assigned respirators.

4.5 Office Safety Coordinators are responsible for coordinating annual respirator training for all employees who are required to wear a respirator.

4.6 Office Safety Coordinators are also required to develop a cartridge/canister change schedule based on available data for each job where employees wear respirators:

- If the nature of the work changes, including temperature, humidity, air flow through the filter, work rate, or the presence of other potential interfering chemicals, the cartridge/canister change schedule should be reviewed and amended as necessary.

5. PROCEDURE

5.1 Respirator Selection:

5.1.1 Respirators are selected on the basis of the potential hazards to which employees are likely to be exposed using the criteria specified in 29 CFR 1910.134(d). The following factors are addressed:

- The specific contaminants known or suspected to be present.

- The concentrations of contaminants known or expected.
- Skin absorption potential of the contaminants.
- Adequate warning properties for each contaminant so that respirator cartridge break-through can be detected.
- Noticeable warning properties that signal respiratory failure.
- Whether the expected contaminant is an eye irritant, a toxic dust, or a skin irritant.
- Whether there is an adequate supply of oxygen in the contaminated atmosphere.
- Whether an IDLH atmosphere exists.

5.1.2 The Selecting Respiratory Protective Devices figure provides guidance on respirator selection, and assists in identifying the type of respirator appropriate for a given application.

5.1.3 The Respirator Selection Form is used when complex mixtures of chemicals require a detailed analysis of data for respirator selection.

5.1.4 Respiratory protection used for a specific activity at a specific site is selected based on the criteria previously outlined within this program and specified in the Site-Specific HASP. The type of respirator selected should be reviewed and approved by the Office Safety Coordinator prior to use.

5.1.5 National Institute for Occupational Safety and Health (NIOSH) approved respirators will be selected and used on the basis of type and expected concentration of specific contaminant(s) known or suspected of being present.

5.1.6 Purchases of respirators and respirator parts should be approved by the Office Safety Coordinator. Where appropriate, employees will be assigned respirators for their exclusive use (i.e., when respirator use is required for extended periods of time).

5.2 Respirator Systems:

5.2.1 Respirator systems are described as follows:

- Air Purifying Respirator – A personal protective device worn, at a minimum, over the nose and mouth, with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.
- Negative Pressure Respirator - A respirator in which the air pressure inside the face piece is negative during inhalation with respect to the ambient air pressure outside the respirator.
- NIOSH – National Institute of Occupational Safety and Health.

- Permissible Exposure Limit (PEL) - Enforceable, regulatory limits set by Occupational Safety and Health Administration (OSHA) on the amount or concentration of certain chemicals in air without presenting a health hazard.

- Powered Air Purifying Respirator (PAPR) - An air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

- Positive Pressure Respirator – A respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

- QLFT - A pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's sensory response to the test agent.

- QNFT – An assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

- SCBA – An atmosphere supplying respirator which supplies the user with breathing air from a source independent of the ambient atmosphere.

5.3 Respirator Canister/Cartridge Change-out Schedule:

5.3.1 For protection against gases and vapors, canisters/cartridges shall be changed in accordance with the change-out schedule established within the TRC Site-Specific HASP.

5.3.2 When available, the ESLI shall be utilized to determine when canisters/cartridges shall be changed.

5.3.3 For contaminants consisting primarily of particles with Mass Median Aerodynamic Diameters (MMAD) of at least 2 micrometers, any filter certified for particulates by NIOSH shall be used.

5.3.4 **Note:** Change-out schedules for most common contaminates at listed concentrations are provided through individual cartridge manufacturers [https://www.osha.gov/SLTC/etools/respiratory/change_schedule.html].

5.4 Respirator Cleaning and Disinfecting:

5.4.1 Respirators will be cleaned and disinfected regularly. Respirators issued for an employees exclusive use will be cleaned after each day's use, or more often if necessary.

5.4.2 Respirators used by more than one employee will be cleaned and disinfected after each use. The following procedures will be used for washing and disinfecting respirators.

- Remove filters, cartridges, or canisters. Disassemble face pieces by removing speaking diaphragms, demand and pressure-demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.

- Wash components in warm water with a mild detergent. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.
- Rinse components thoroughly in clean, warm water.

5.4.3 When the cleaner or detergent used does not contain a disinfecting agent, respirator components should be immersed for 2 minutes in one of the following:

- Hypochlorite solution (50 ppm of chlorine) made by adding approximately 1 milliliter of laundry bleach to 1 liter of water.
- Aqueous solution of iodine or (50 ppm iodine) made by adding approximately .8 milliliters of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45 percent alcohol) to one liter of water at.
- Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer.

5.4.4 Rinse components thoroughly in clean, warm water. The importance of thorough rinsing cannot be over-emphasized. Detergents or disinfectants that dry on face pieces may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

5.4.5 Components should be hand dried with a clean lint-free cloth or air dried.

5.4.6 Reassemble face-piece, replacing filters, cartridges, and canisters, where necessary.

5.4.7 Test the respirator to ensure that all components work properly.

5.5 Respirator Storage and Maintenance:

5.5.1 When not in use, respirators will be stored to protect against dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals.

5.5.2 Clean resealable plastic bags or other equivalent containers will be used to store respirators after each day's use or for prolonged periods of time.

5.5.3 Major maintenance or repairs will be done with parts specifically designated for the respirator, and only by qualified and experienced persons.

5.5.4 Respirators requiring repair or major maintenance will be sent to the manufacturer or manufacturer-approved repair shop if a qualified repair person is not available.

5.6 Respirator Inspection:

5.6.1 Prior to each day's use, respirators will be inspected, at a minimum, for the following:

- Cracks, tears, decomposition, face piece distortion.
- Holes, cracks, or tears in the exhalation or inhalation valve.
- Worn or stretched headbands.
- Cracked valve covers.
- Worn or loose head strap and snap fasteners.
- Missing or deteriorated gaskets.

5.6.2 For respirators maintained for emergency use, inspections shall be monthly at a minimum, and shall be certified by documenting the date the inspection was performed, the name of the person who made the inspection, and any remedial action that might be necessary.

5.7 Industrial Hygiene Surveillance:

5.7.1 TRC conducts appropriate work area surveillance to determine the need and adequacy of respiratory protection when necessary.

5.7.2 The nature and extent of industrial hygiene surveillance is identified during each site hazard assessment, and are specified in the Site-Specific HASP.

5.7.3 Levels of protection and the concentration limits for upgrading or downgrading respiratory protection are specified in the Site-Specific HASP.

6. MEDICAL EVALUATION

6.1 TRC employees will not be assigned to tasks requiring respirators until a medical evaluation questionnaire has been completed using the criteria specified in 29 CFR 1910.134, and a physician has determined that the employees are physically able to perform the work using required Personal Protective Equipment (PPE).

6.1.1 The medical evaluation questionnaire is developed and maintained by the servicing occupational health clinic in accordance with 29 CFR 1910.134.

6.2 The respirator user’s medical status is reviewed annually at a minimum, or more frequently at the discretion of the examining physician.

7. EMPLOYEE TRAINING

7.1 Respirator inspection, use, storage, and limitation training is provided to all respirator users. Respirator training will be conducted annually and more often if necessary.

7.2 Respirator training program topics will include the following:

- Respiratory protection needs.
- Respirator parts and functions.
- Respirator fit.
- Respirator limitations.
- Common contaminants found on a job.
- Face-to-face piece seal.
- Fit-testing purpose.
- Positive and negative pressure tests.
- Qualitative and quantitative fit testing.
- Respirator cleaning and disinfecting.
- Medical evaluation.
- Respirator maintenance.
- Respirator types and capabilities.
- Respirator storage.
- User's responsibility for respirator inspection prior to each use.

8. SCBA AND AIR-LINE RESPIRATORS

8.1 An SCBA or an air-line respirator is required for Level B protection. An SCBA or air-line respirator provides breathing air to the user in hazardous atmospheres. Breathing air shall meet or exceed the requirements of the specifications for Grade D breathing air described in the American National Standards Institute (ANSI)/Compressed Gas Association Commodity Specification G-7.1, 1989. Compressed oxygen will not be used in SCBA or air-line respirators. Breathing air may be supplied to respirators from cylinders or air compressors. The compressor for supplying air must be equipped with the necessary safety and standby devices as defined in OSHA Standard 29 CFR 1910.134(i).

8.2 Air-line respirators used in IDLH atmospheres will have an egress unit (minimum 5-minute breathing air supply) for emergency use. The SCBA will have an alarm indicating a low air level in the cylinder.

8.3 Breathing air containers must be marked in accordance with ANSI's Method of Marking Portable Compressed Gas Containers.

8.4 The buddy system will be used whenever an SCBA or air-line respirator is used. Communications (visual, vocal, or signal) will be maintained between individuals. When an SCBA or air-line respirator is used in IDLH atmospheres, a standby person will be present with suitable rescue equipment.

8.5 Special training is required for users of air-supplying respirators (SCBA or air-line). Training provides persons with an opportunity to handle the respirator, test its face-to-face piece seal, and wear it for a familiarity period. Specific training is required for the specific model of air-supplying respirator used. Employees using an air-supplying respirator will receive refresher training in the use of such a respirator prior to each job on which it must be used.

8.6 Air-supplying respirators will be inspected before and after each use and monthly at a minimum to determine proper functioning of the regulator and warning devices.

9. RESPIRATOR FIT TESTING

9.1 Individuals using respirators are fit-tested in a test atmosphere in accordance with the criteria specified in 29 CFR 1910.134 (Appendix A) to determine the respirator make, model, and size that provides a proper fit.

9.2 QLFT is performed with the stannic chloride smoke tubes testing protocol when a protection factor of 10X or less is required for negative pressure respirator, or any positive pressure respirator up to the Applied Protection Factor (APF) unless other test methods are required by applicable OSHA standards.

9.3 QTFT will be performed using a TSI Portacount when a protection factor of greater than 10X is required. The results of the fit testing for each individual are documented on a Respirator Fit Test Certification Form (see the QLFT Form and the QTFT Form) and are filed for future reference.

9.4 Employees are provided the make, model, and size of respirator that provided the optimum fit during the most recent fit test.

9.5 Respirator fit tests will be conducted annually unless they are specified more often (i.e., asbestos and lead exposure fit tests are conducted every six months).

9.6 Respirators cannot be worn when conditions such as the presence of facial hair prevent a good face-to-face piece seal.

9.7 The user must check the facepiece fit using the positive and negative pressure tests each time the respirator is worn.

9.8 If any of the following danger signals are experienced using a respirator, personnel will immediately evacuate the respirator area and will inform the site Health and Safety representative.

- Chemical smell or taste.
- Eye, nose, or throat irritation.
- Breathing difficulty.
- Chest pain.
- Nausea, dizziness, or loss of equilibrium.

10. REFERENCES/RELATED DOCUMENTATION

CP002 – Risk Analysis/Site-Specific Health and Safety Program

29 CFR 1910.134 Respiratory Protection

Qualitative Fit Testing Form

Quantitative Fit Testing Form

Selecting Respiratory Protective Devices Figure

Respirator Selection Form

1. PURPOSE

The Hearing Conservation Program has been established to help ensure that TRC employees do not suffer health effects from exposure to excessive noise while at work.

2. SCOPE

The program applies to all part- and full-time TRC employees.

3. DEFINITIONS

Action Level: An 8-hour Time-Weighted Average (TWA) of 85 decibels measured on the A-weighted scale, slow response, or equivalently a dose of 50%. This is the level of sound exposure at which employee participation in the Hearing Conservation Program is mandatory.

A-Weighted Sound Level (dBA): The weighting of sound levels that represents the function of the human ear.

Audiometric Testing Program: The portion of the Hearing Conservation Program that consists of measuring an employee's hearing threshold to establish a baseline and for subsequent comparisons.

Decibel (dB): Unit of measurement of sound level.

Dose: A ratio of noise exposure relative to the noise criterion level of 90 decibels, expressed as a percentage. Ninety decibels represents a dose of 100% over an 8-hour work shift. Eighty-five decibels represents a dose of 50% over an 8-hour work shift. Dose is based on the Occupational Safety and Health Administration (OSHA) 5 dB exchange rate. Dose may be determined from the equation given in Table 1 (See Appendix A) for non-continuous noise or estimated from Table 2 (see Appendix B) based on the TWA.

Hearing Conservation Program: A written program that establishes procedures to ensure the protection of employees from high noise areas or operations in compliance with the OSHA Occupational Noise Regulation 29 CFR 1910.95.

Hearing Protection Attenuation: The estimated reduction in the noise level at the eardrum as a result of the use of hearing protection. Estimated using the formula: Attenuated TWA, dBA = TWA - (Noise Reduction Rating, (NRR), – 7) for A–scale weighted sound levels. Attenuated TWA, dBC = TWA – NRR for C-scale weighted sound levels.

Noise Induced Hearing Loss (NIHL): The OSHA recordable occupationally related hearing loss, as defined by 29 CFR 1904.10 and 29 CFR 1904.5, and includes a Standard Threshold Shift (STS) of 10 db, with age correction, averaged over the 2K, 3K, and 4K frequencies from baseline in either ear and a 25 db shift from audiometric zero, in the same ear as the 10 dB STS at the same frequencies.

Noise Reduction Rating (NRR): The theoretical maximum amount of noise reduction that can be achieved using a hearing protection device. This is a manufacturer's calculated value and must be displayed with the hearing protection device.

Monitoring: The sampling of noise levels using a sound level meter, octave band analyzer, or personal noise dosimeter.

Permissible Noise Exposure: The maximum daily noise exposure which may be experienced by employees not using hearing protectors from a continuous 8-hour exposure to a sound level of 90 dBA or equivalent dose of 100%.

Standard Threshold Shift (STS): A change in hearing threshold, relative to the most recent audiogram for that employee, of an average of 10 decibels (dB) or more at 2000, 3000, and 4000 hertz in one or both ears and substantiated within 30 days with a follow-up audiogram.

Time-Weighted Average (TWA): The [equivalent] noise level, in dB, based on an 8-hour exposure timeframe. If the noise is not constant over an 8-hour exposure, then a calculated 8-hour TWA must be made using the equation in Table 1 (see Appendix A). The TWA may also be estimated from the dose or percent noise exposure, based on noise exposure continuous over 8 hours, as given in Table 2 (see Appendix B).

4. RESPONSIBILITIES

4.1. The National Safety Director and Corporate Safety Manager are responsible for establishing the Hearing Conservation Program requirements, and providing/communicating to TRC employees.

4.2. The Human Resources Department will coordinate baseline audiometric testing for new hire employees in the Hearing Conservation Program.

4.3. The Project Managers will assist with identifying areas and tasks that may cause employees to exceed OSHA's hearing conservation level of 85 dBA TWA. They will also ensure that employees required to participate in the Hearing Conservation Program complete their annual audiometric testing.

4.4. Office Safety Coordinators are responsible for assisting Project Managers in identifying tasks/areas that may require hearing protection and list this information in the HASP.

4.5. An Industrial Hygienist may be asked to perform noise monitoring to characterize employee exposure levels to noise.

4.6. Employees are responsible for reviewing and complying with the program. Employees will also assist the Project Managers in identifying potentially hazardous noise locations or operations that have noise levels above 85 dBA.

5. PROCEDURE

5.1. Monitoring:

5.1.1 When information indicates that employees' exposure may equal or exceed the action level of 85 dBA for an 8-Hour TWA assessment, personal noise monitoring shall be conducted. Affected employees shall be notified of the results of the monitoring where levels at or above the action level are identified. Monitoring activities may consist of:

- Sound level measurements for locations where the noise level is stationary and expected to be continuous. Monitoring will be documented using the Area Noise Survey Data Form (see Appendix C); or
- Personal noise dosimeter for work operations which are highly mobile or random in noise level. Monitoring will be documented.
- Re-monitoring, if a change in equipment, process or controls increases the noise level to the extent that:
  - Additional employees may be exposed at or above the action level or;
  - The attenuation provided by the hearing protectors used by the employee(s) does not reduce the noise exposure level to 90 dBA for an 8-hour TWA or 85 dBA for an 8-hour TWA for employee(s) that have experienced a standard threshold shift.
  - An STS has occurred, and follow-up monitoring is required.
- The opportunity for affected employees to observe the noise measurements during the collection.

5.2. Audiometric Testing and Training Program:

5.2.1. All employees exposed to noise at or above the OSHA's hearing conservation action level are required to participate in the Hearing Conservation Program. This program consists of:

- A baseline test to be completed within 6 months of the employee's first exposure above the action level. This test must be preceded by at least 14 hours without exposure to workplace noise at or above 85 dBA or hearing protection devices must be used prior to testing.
- Annual testing thereafter provided that exposure at or above the action level is expected.
- If a standard threshold shift has occurred, employees will be notified in writing within 21 days of the determination. The engineering controls and hearting protectors will be re-evaluated and/or refitted.
- A follow-up audiogram will be provided within 30 days of a standard threshold shift.

- Training of affected employees regarding the hazards of noise exposure, and where necessary the fitting of employees with appropriate hearing protection devices and training about their use, care and limitations.
    - Training will occur before initial assignment, on at least an annual basis, and will be updated to be consistent with changes in PPE and work processes.

5.3. Noise Control:

5.3.1. Where noise levels are non-mobile sources found to be in excess of 90 dBA or above the Permissible Noise Exposure as listed in Table 1 (see Appendix A) on a continuous basis and employees are required to work in such area, the following measure shall be taken:

- Engineering controls will be evaluated for feasibility in noise reduction. Until they are implemented or if adequate controls are not feasible then;
- Hearing protection devices shall be worn by employees whose exposure is at or above 90 dBA as an 8-hour TWA. Hearing protection attenuation shall reduce the exposure below 90 dBA as an 8-hour TWA using the NRR of the rated device.
- For employees exposed to noise levels at or above 85 dBA, but below 90 dBA as an 8-hour TWA, the use of hearing protection devices shall be strongly encouraged and provided at no cost to the employee. The employee will also be given an opportunity to select their own hearing protection based on TRC's selection.

5.4. Recordkeeping:

5.4.1. Audiometric test results will be maintained by a third party vendor, on behalf of TRC. Noise monitoring records will be maintained on the project site and with the Project Manager for at least two years. Employees will receive copies of personal sampling data and will be provided access to all records upon request.

6. REFERENCES

29 CFR 1910.95 Occupational Noise Exposure

7. APPENDICES

Appendix A: Table 1

Appendix B: Table 2

Appendix C: Area Noise Survey Data Form

Appendix D: Noise Dosimetry Data Sheet

APPENDIX A

TABLE 1

TABLE 1: 8- HOUR TWA SOUND LEVELS & ALLOWABLE EXPOSURE TIMES

Sound Level (dBA) (loudness)	**Allowable Exposure Duration** (Hours)
80	32
85	16
90	8
95	4
100	2
105	1
110	0.5
115	0.25
120	0.125
125	0.063
130	0.031

For brevity, only dBA values that are multiples of 5 are shown. Shaded areas represent OSHA-defined exchange rate. The complete table G-16A at 29 CFR 1910.95 App A will be used. Allowable exposure duration is time in hours at a dBA level, which constitutes an exposure equivalent in energy and sound dose to 90 dBA for 8 hours.

Calculations/Definitions:
Allowable exposure time may be calculated using the following equation for sound levels not specified in this table:

$T = 8/2^{(L-90)/5}$

Where T = Allowable Exposure Duration and
L = measured A-weighted sound level.

Example: measured sound level = 75 dBA

$T = 8/2^{(75-90)/5}$ = 64 hours Allowable Exposure Duration

Sound levels below 80 dBA are not included in exposure calculations. A dose of 50% or more, or an 8-hour TWA of 85 dBA or higher, triggers the Action Level requirements and mandates an employee's participation in the Hearing Conservation Program.

APPENDIX B

TABLE 2

TABLE 2: PERCENT NOISE EXPOSURE (DOSE) AND EQUIVALENT 8-HOUR TWA

Dose (%)	8-Hour TWA
10	73.4
20	78.4
30	81.3
40	83.4
50	85.0
60	86.3
70	87.9
80	88.4
90	89.2
100	90.0
120	91.3
140	92.4
160	93.6
180	94.2
200	95.0
240	96.3
280	97.9
300	97.9
400	100.0
500	101.6

For brevity, a shortened selection of dose values are shown. The complete list is given in Table A-1 of 29 CFR 1910.95, Appendix A.

The dose may be calculated using the following formula:
Dose = 100 x $\{(C_{Level1})/(T_{Level1})+(C_{Level2})/(T_{Level2})+(C_{Level\ n})/(T_{Level\ n})\}$
Where C = time of exposure at any noise level and
T = allowable exposure time, in hours given by Table 1.

<u>Example</u>: 100 dBA for 1 hour, 95 dBA for half hour, and 80 dBA for 4h
Dose = 100x{1/2 + 0.5/4 + 4/32} = 100x(0.5 + 0.125 + 0.125} = 75% For a dose greater than or less than the values printed in the chart use the following equation to calculate the TWA:
8h-TWA = 16.61 log(10) (D/100) + 90
Where D = accumulated dose in percent exposure. <u>Example</u>: Dose = 75%
8h-TWA = 16.61 log(.75) + 90 = 16.61(-.1249) + 90 = -2.07 + 90 =
87.93 dBA

APPENDIX C

AREA NOISE SURVEY DATA FORM

AREA NOISE SURVEY DATA FORM

Sound Level/Octave Band Data

Name: ______________________ Date: ______________________

Location: ______________________ Noise Source: ______________________

Manufacturer: Model/Serial #:

Threshold: 80 dB Exchange Rate: 5 dB

Are Hearing Protectors used? ☐ Yes ☐ No If yes, what percentage? 5%

Monitoring Conducted by:

Calibration Checks

Date/Time	Frequency	Initial Setting	Date/Time	Frequency	Final Setting
	125 Hz	dB		125 Hz	dB
	250 Hz	dB		250 Hz	dB
	500 Hz	dB		500 Hz	dB
	1000 Hz	dB		1000 Hz	dB
	2000 Hz	dB		2000 Hz	dB
Calibrator:			Serial #:		

Testing Results

Sample Location	Result	Sample Location	Result
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
	dBA		dBA
Comments:			

APPENDIX D

NOISE DOSIMETRY DATA SHEET

NOISE DOSIMETRY DATA SHEET

Name: ______________________ Date: ______________________

Job Title: ______________________

Dosimeter Manufacturer: ______________________ Model & Serial #: ______________________

Work Location Description: ______________________

Threshold: 80 dBA Criterion Level: 90 dBA Exchange Rate: 5 dBA

Microphone Location: ______________________

Monitoring Conducted: ☐ Personal ☐ Area

Are Hearing Protectors Used? ☐ Yes ☐ No

If yes, what percent of the workday? 5%

Exposure Description

Calibration Check

Date	Initial Reading	Time	Final Reading	Time

Dosimetry Data

Date	115 dBA Exceeded	Start Time	Stop Time	Display Reading %	L eq(t)

1. PURPOSE

The purpose of the this Health and Safety Training Program is to provide the method identifying health and safety training requirements for employees based on their job assessments and legal requirements.

2. SCOPE

The plan applies to all full-time and part-time employees.

3. RESPONSIBILITIES

3.1 TRC's National Safety Director, or designee, is responsible for determining which training topics are required for employees based on legal requirements and company policy.

3.2 Supervisors are responsible for identifying health and safety training requirements for their employees, based on information in this plan and guidance from TRC's Safety Department and TRC's Training Coordinator.

3.3 TRC's Training Coordinator is responsible for assigning employees training topics in the TRC Safety Academy.

3.4 Employees are responsible for participating in completion of the Health and Safety Training Maps based on their job assignments. Employees are also responsible for completing assigned training topics.

4. PROCEDURE

The Health and Safety Training Checklist (CP009.1) shall be completed by the Employee's Supervisor with input from the employee and a member of TRC's Health and Safety Network as necessary. The Health and Safety Training Checklist should be completed during new hire orientation, reviewed during new job assignments, and at least annually thereafter.

The Checklist is completed electronically and provided to TRC's Training Coordinator. The affected employee and the Supervisor can review the updated Plan through the TRC Safety Academy. The employee should be instructed by his/her Office Safety Coordinator (OSC) on the training courses selected for review.

The Health and Safety Training Map (CP009.2) contains information on each training topic that can be used to identify training courses. This information is also embedded within the form. When using the Checklist, the applicability of the information in the Training Map will guide you to the appropriate yes/no box.

Health and Safety Training Checklist

Instructions: If training is required, click on the "Y" box. It will be assumed that all empty boxes are not required. All TRC employees must have a Plan completed with their Supervisor.

Employee Name: ____________________

Office Location: ____________________

Office Location: ____________________

Employee Number: ____________________ **Date of Last Review:** ____________________

Indicate One: ☐ New Plan ☐ Update to Existing Plan (update applicable fields only)

Company-wide Required Training:

Y	
☒	TRC H&S Orientation (required for all employees)

Job-specific Required Training:

Y	N	
☐	☒	Annual Physical Examination (1 Year)
☐	☒	Biennial Physical Examination (2 Year)
☐	☒	Baseline Physical Examination
☐	☒	Respiratory Protection Program
☐	☒	Exit Physical Examination
☐	☒	40-hour HAZWOPER
☐	☒	3-day HAZWOPER Supervised On Site
☐	☒	8-hour HAZWOPER Refresher
☐	☒	8-hour Supervisor HAZWOPER
☐	☒	OSHA 10-hour Construction
☐	☒	Confined Space Training
☐	☒	First Aid/CPR
☐	☒	MSHA (Mine Safety)
☐	☒	Troxler Radiation Safety
☐	☒	NITON Radiation Safety
☐	☒	Lockout/Tagout
☐	☒	Asbestos Exposure
☐	☒	Lead Exposure
☐	☒	Benzene Exposure
☐	☒	Construction
☐	☒	Construction & Heavy Equipment
☐	☒	Field Safety Training
☐	☒	PPE (Personal Protective Equipment)

Health and Safety Training Checklist

☐ ☒ Laboratory Chemical Hygiene Plan

Y	N	
☐	☒	H2S (Hydrogen Sulfide)
☐	☒	Bloodborne Pathogens
☐	☒	H&S Driver & Vehicle Safety Management Manual
☐	☒	DOT Driver (DL4 or DL5)
☐	☒	DOT Drug & Alcohol Reasonable Suspicion for Supervisors
☐	☒	DOT HazMat Transportation
☐	☒	IATA Hazmat Air Transport Dangerous Goods
☐	☒	Electrical Safety – Qualified Person
☐	☒	Office Safety
☐	☒	Office Ergonomics
☐	☒	Fire Safety: Extinguishing Risk
☐	☒	Practice-Specific - RMD
☐	☒	Practice-Specific - PDE
☐	☒	Practice-Specific - TRD
☐	☒	Practice-Specific - GDR
☐	☒	Practice-Specific - PPL
☐	☒	Client-Specific Training
☐	☒	APPA (American Public Power Association)
☐	☒	Storm / Disaster Recovery Task Team Training

Signatures

Office Safety Coordinator: ____

Employee: ____

Supervisor: ____

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
TRC H&S Orientation	Required for all employees.	Initial only	Training is conducted by an Office Safety Coordinator (OSC), and follows the training agenda outlined on the TRC H&S Intranet site directory.
First Aid/CPR	Required for all TRC personnel who will be regularly working on remote field projects that do not have medical services readily available. For this application, "regularly working" shall be defined as 30 days or more per year.	Depends on service provider: • *American Red Cross* requires an update training every year for CPR and every 3 years for First Aid. • *American Heart Association* requires an update training every 2 years for both CPR and First Aid.	For employees who, due to their job function, are required to have First Aid and CPR, the training will be offered during normal business hours. For employees who wish to receive this training but are not required to have it, TRC will furnish the training to those employees at no cost after normal business hours.
40-hour HAZWOPER	Required for employees who either will work on project sites where hazardous substance removal/ remediation could potentially expose them to health hazards associated with this work, or for those employees who serve as project managers for these projects.	Initial only unless >36 months since last 8-hour refresher.	Training will be provided by an outside resource that has established a program that complies with the training requirements of 29 CFR 1910.120.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
8-hour HAZWOPER Refresher	Required for employees who, because of their job function, were required to complete 40-hour HAZWOPER training and will be involved in hazardous waste/material remediation, cleanup, and/or other activities that will expose the employee to uncontrolled hazardous substances.	Annual refresher	The OSC may choose to conduct the annual refresher training in-house using local resources as long as the employees who conduct the training are competent in the subject matter. Offices that do not have in-house resources available, may utilize online training resources that comply with the training requirements of 29 CFR 1910.120.
8-hour Supervisor HAZWOPER	Required for employees who, because of their job function, were required to complete 40-hour HAZWOPER training. Required for those individuals who are responsible for or who supervise employees engaged in hazardous waste operations.	Initial – One time only. Followed by annual 8-hour HAZWOPER Refreshers.	The OSC may choose to conduct the annual refresher training in-house using local resources as long as the employees who conduct the training are competent in the subject matter. Offices that do not have in-house resources available may utilize online training resources that comply with the training requirements of 29 CFR 1910.120. In general, this would be all TRC personnel who are involved in HAZWOPER work, as most projects use subcontract resources with TRC on-site management.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
3-day HAZWOPER Supervised On Site	Required for employees who are required to have 40-hour HAZWOPER training and will be involved in on-site hazardous waste/materials remediation or cleanup.	Initial	Required for all employees after completion of 40-hour HAZWOPER training, once the employee physically enters the project site. Three-day time period may be spread over more than one site if time at project location does not exceed 3 days. For an employee to skip this requirement, he or she must be able to provide documentation of completion.
Confined Space Training	Required for employees who will be involved with on-site confined space without regards to the nature of the confined space being permitted or non-permitted.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements. The Confined Space Program material can be obtained from the TRC Intranet H&S site directory.
OSHA 10 -hour Construction	Required for all construction management personnel and other employees who will be monitoring or overseeing construction activities (i.e., excavations, scaffolding, fall protection).	Every 5 Years	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Baseline Physical Exam	Required for all new employees who will perform field work on HAZWOPER projects regardless of duration.	Initial at employment	A baseline physical will be conducted initially for all employees involved in TRC's ***Medical Surveillance Program***. Employees who will be on HAZWOPER sites less than 30 days per year will not be required to have an annual or biennial examination.
Annual Physical Exam	Required for employees working on HAZWOPER projects who will wear a respirator 30 days or more per year.	Baseline physical at employment followed by an annual exam.	The determination of 30 days of respirator use is as follows: if a respirator is used, either we know the levels to be at or above the PEL, and engineering controls are not an option, or we do not have monitoring data, and therefore, must protect to the highest level.
Biennial Physical Exam	Required for employees who will be exposed to fieldwork on HAZWOPER sites 30 days or more per year.	Baseline physical at employment followed by a biennial exam.	Biennial physicals will make up the majority of TRC personnel involvement in the ***Medical Surveillance Program***. These are employees who are working on HAZWOPER sites 30 days or more per year but are not required to wear respirators for protection because exposure levels are known to be below the PEL during the particular field operation being performed.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Respiratory Protection Program	Required for all employees who will wear a respirator or who work on sites where there is potential for exposure to hazardous substances above the PEL.	• Training - Initial • Fit testing - Annual Review Respiratory Protection Program for guidelines on which fit testing procedure is required. Level A = Quantitative Level B = Qualitative • Physical – Initial, with follow-up physical biennially.	In most cases this will be HAZWOPER-trained employees who will be engaged in hazardous waste remediation/cleanup. Managers who are required to have HAZWOPER training because they manage those types of projects, but will not be involved in the ongoing work at the project, can be excluded. The Respirator Protection Program can be found on the TRC Intranet H&S site directory. This training may be covered during the annual 8-hour HAZWOPER Refresher course to meet the initial training requirements.
Exit Physical Exam	Required for all employees who received a baseline physical at employment, or who have participated in TRC's ***Medical Surveillance Program***.	Prior to last day of employment.	An employee's exit physical should be conducted prior to the employee's last day of employment with TRC. If an employee refuses to have the exit physical, ensure that this is documented in writing and signed by the employee and OSC. Ensure that the exit exam refusal documentation is forwarded to Human Resources and to the National Safety Director for filing.
Troxler Radiation Safety	Required for employees who will be using a Troxler nuclear gauge.	Initial 8-hour through manufacturer, and 1 hour in-house with the RSO.	Some states require an annual training update after completion of the initial 8-hour training. Contact Mario Marra, TRC Radiation Safety Officer (RSO).

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
NITON Radiation Safety	Required for employees who will be using a NITON XRF gauge.	Initial 8-hour through manufacturer and 1-hour in-house with the RSO.	Some states require an annual training update after completion of the initial 8-hour training. Contact Mario Marra, TRC Radiation Safety Officer (RSO).
(MSHA) Mine Safety	Required for employees who will be exposed to active parts of cement plants, quarries, or mines more than 6 days in any given month.	Annual	Training will be provided by an outside resource that has established a program that complies with the governing Mine Safety and Health Act (MSHA) regulations, or by the Office Safety Coordinator (OSC) following TRC's MSHA training program.
Lockout/Tagout	Required for all employees who will be involved with on-site project work that would give exposure to accidental hazardous releases of energy (i.e., groundwater recovery systems, breaker panel upstream from equipment repair).	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. The TRC Lockout/Tagout Program is located on the TRC Intranet H&S site directory.
Asbestos Exposure	Required for all employees who have potential exposure to asbestos.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Lead Exposure	Required for all employees who have potential exposure to lead.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Construction	Required for all field construction employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Construction & Heavy Equipment	Required for all field construction employees who work with heavy equipment.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Field Safety Training	Required for all field service employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
PPE (Personal Protective Equipment)	Required for all employees who will be conducting on-site project work, including, but not limited to: Head Protection, Eye & Face Protection, Hand and Arm Protection, Body Protection, Foot Protection, Hearing Conservation, and Respiratory Protection.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Laboratory Chemical Hygiene Plan	Required for laboratory workers.	Initial only unless new hazards are introduced and the plan is changed.	Training will be given by the laboratory supervisor or other employees recognized to be competent in the program requirements according to the program outline. TRC's Laboratory Safety Program is located on the TRC Intranet H&S site directory.
H2S (Hydrogen Sulfide)	Required for all employees working in an area where concentrations of H2S may exceed 10 parts per million (PPM).	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Benzene Awareness	Required for all employees who have potential exposure to Benzene	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Bloodborne Pathogens	Required for employees who are exposed to Bloodborne pathogens as a result of their job duties.	Initial - Some instances may require annual renewal.	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Note: The student must be able to ask the instructor questions during the training session.
DOT HazMat Transportation (Hazardous Materials Shipping)	Required for employees who will transport, ship, or receive hazardous materials.	Initial at employment and then every 3 years. Note frequency changes with some state plans.	The DOT Hazardous Training Materials Program can be found on TRC on-line H&S site directory under H&S programs. This material can be covered during the 8-hour HAZWOPER Annual Refresher to meet the frequency requirements or covered in a stand-alone training session.
IATA HazMat Air Transport Dangerous Goods	Required for employees who will transport hazardous materials by air. A prerequisite is the DOT Hazardous Materials Shipping course.	Initial at employment and then every 2 years (If applicable).	The DOT Hazardous Training Materials Program can be found on TRC on-line H&S site directory under H&S programs. This course requires a prerequisite course - ***DOT HazMat Transportation***.
Electrical Safety – Qualified Person	Required for all employees working on or near potentially energized electrical equipment over 50 volts.	Initial training that is appropriate to the type of work and level of potential hazards the employee will be exposed to.	Training can be performed through a combination of formal classroom and on-the-job instruction.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
H&S Driver & Vehicle Safety Management Manual	Required for all employees for general vehicle safety.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
DOT Drivers	Required for TRC DOT DL 4s and DL 5s who drive a fleet vehicle that weighs 10-26k or 26k, respectively.	Annual	Training can be performed through online resources.
DOT Drug & Alcohol Reasonable Suspicion for Supervisors	Required for all supervisors that need to make a reasonable suspicion determination.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements of 49 CFR Part 40.
Fire Safety: Extinguishing Risk	Required for all employees who are expected to use a portable fire extinguisher as part of their job assignment.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Office Safety	Required for all employees working in an office environment.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Office Ergonomics	Required for all employees working in an office environment.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Practice-Specific - RMD	Required training for all RMD employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Practice-Specific - PDE	Required training for all PDE employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
Practice-Specific - TRD	Required training for all TRD employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Practice-Specific - GDR	Required training for all GDR employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Practice-Specific - PPL	Required training for all PPL employees.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Client-Specific Training	Required client-specific training for all employees allocated for those sites.	Initial – Can be annual or biennial based on client request.	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

Health and Safety Training Checklist

Health and Safety Training Map

H&S Training Criteria

TRAINING TOPIC	APPLICABILITY	FREQUENCY	GENERAL INFORMATION
APPA (American Public Power Association)	Required for all employees working at a publicly-owned electric utility.	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.
Storm/Disaster Recovery Task Team Training	Required for all employees participating in the Disaster Recovery Task Team Program. Includes: Wires Down & EHA (Electrical Hazard Awareness)	Initial	Training can be conducted in-house or by using outside resources pending the experience and competency of the in-house trainer. Offices that do not have in-house resources may utilize the online training resources that comply with the training requirements.

1. PURPOSE

The Behavior-Based Safety (BBS) Program has been developed for TRC, and can be defined as the process of increasing the frequency of performing safe work habits through observation and feedback. As the term implies, safe work habits are those behaviors (or employee actions) that are routine or performed as a reflex, without much thought. The performance of safe work habits is a learned behavior, and is improved by observing others' work activities and providing instructional feedback on how the work was performed.

When at-risk behaviors are identified and reduced and communication improves, the safety culture of the project improves; all leading to less injuries and a safer work environment.

The purpose of this BBS Program is to re-enforce safe work habits and identify and discuss at-risk behaviors that may lead to workplace injuries.

2. SCOPE

This program applies to all TRC employees performing work outside of their home office location.

3. DEFINITIONS

<u>Observation</u>: A planned site visit conducted by a trained employee who will observe a given task.

<u>Incident</u>: A work-related event in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.

4. RESPONSIBILITIES

4.1 National Safety Director:

4.1.1 The National Safety Director is responsible for establishing BBS Program requirements and providing/communicating to TRC employees. The National Safety Director will also review BBS observation findings on a monthly basis, and encourage participation in the BBS Program. The National Safety Director also executes observations on a routine basis.

4.2 Corporate Safety Manager:

4.2.1 The Corporate Safety Manager will review the BBS observation findings on a monthly basis and assist the National Safety Director in establishing the BBS Program. The Corporate Safety Manager will conduct observations on a quarterly basis at a minimum.

4.3 Health and Safety Network:

4.3.1 The Health and Safety Network is responsible for BBS Program implementation including, but not limited to:

- Training new and existing TRC site employees on BBS observation procedures (see Section 5.2 Training).
- Executing BBS observations.
- Assisting with the collection of BBS observation data.
- Communicating and coordinating TRC's BBS requirements with all TRC Subcontractors including identification of Subcontractors' Competent Person(s).
- Working in concert with identified observers to provide on-site direction on BBS implementation issues.
- Providing timely feedback to the project team on the BBS findings.
- Maintaining records for Health and Safety activities on-site including procedural audits of employee BBS Program implementation (see Sections 5.3 and 5.4 on Audits and Inspections, and Documentation).

4.4 Project Manager:

4.4.1 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the BBS Program. Project Managers should be able to support the Health and Safety Network for BBS observations and program audits. The Project Manager shall also review the BBS findings with the project team and Subcontractors and actively participate in the BBS Program.

4.4.2 The Project Manager will participate in feedback sessions with employees in relation to observations conducted on their project sites.

4.5 Site Employee:

4.5.1 Site employees are responsible for understanding the BBS Program elements and requirements and actively participate in the program. Employees are encouraged to recommend improvements to the BBS Program to help its functionality and effectiveness.

5. PROCEDURE

5.1. General Requirements:

5.1.1 Identification of At-Risk Behaviors:

- At-risk behaviors are precursors to injuries. Respected safety authorities report that 80-95 percent of all injuries are the result of at-risk behaviors. If these behaviors are eliminated and safe work habits are developed, the number of injuries decreases.
- The potential at-risk behaviors are listed on page 1 of the Safety Observation Form (SOF) (see Appendix A). Root cause(s) and solution(s) to prevent the potential incident from occurring again are then identified for each at-risk behavior. A responsible person is assigned to complete the implementation of the solution and a due date is assigned. A follow-up observation is then performed for the same task to verify that the at-risk behaviors have been corrected and validate the solution(s). The SOF may undergo periodic revisions as the site work progresses to reflect current activities and operations or to refocus attention on those at-risk behaviors which have not been changed into safe work habits.

5.1.2 Observations of Work Practices:

- Trained observers will perform observations of employee work practices to determine how safely work is being performed and to track the frequency of safe and at-risk behaviors. Announced observations will be performed as work progresses and can occur whenever work is being performed. Individuals charged with performing observations will receive additional training including the observation and feedback process to ensure that they fully understand how the BBS Program will be implemented.
- Supervisors and others trained in the observation process will use the SOFs to document safe and at-risk behaviors and to provide coaching to encourage safe behaviors.

5.1.3 Feedback:

- Feedback is the verbal interaction by the observer with the employee being observed to discuss the results of the observation. This coaching process is intended to accomplish one of the following:
  - Provide positive reinforcement, if safe behaviors are observed.
  - Provide constructive feedback, if at-risk behaviors are observed.
- Positive reinforcement confirms to the employee being observed that the work practice was performed safely. Positive reinforcement encourages a repeat performance of the same safe behavior.

- Constructive feedback is meant to be instructional, to inform the employee observed that his/her behavior may be at-risk of an injury, and to provide alternative examples of how to perform the work safely.
- Prompt and frequent feedback is encouraged as it helps to make certain employees understand what behaviors are safe and should be performed, and which at-risk behaviors should be eliminated. The more frequent and prompt the feedback, the sooner safe work habits can be adopted.
- As indicated in the Site-Specific Orientation, a zero tolerance policy has been established for blatant, willful violations of company policies regarding certain aspects of fall protection, trenching and excavation, lockout/tagout (LOTO), confined space entry, drugs, alcohol, and workplace violence.

5.1.4 Data Collection and Tracking:

- The results of the supervisor observations will be documented on the SOFs which identify the project, date, observer's name, whether safe or at-risk behaviors were performed, and if feedback was provided.
- All SOFs are reviewed by the Health and Safety Network and Project Managers, and the observation data will be entered into a spreadsheet or database for the identification of trends and patterns regarding the number of safe versus at-risk behaviors. By collecting and analyzing the data, an overall understanding of where, when, and why at-risk behaviors are performed can be developed and actions taken to prevent their re-occurrence.
- Based on data collected and patterns identified, performance goals may be established to help improve awareness and program effectiveness. Recognition of achieving these goals may be provided as an incentive to achieve increased safety performance.

5.1.5 Communication:

- The BBS Program is based strongly on employee communication and interaction. Communication, which is essential for the sustainability and success of the program, can occur by various means including:
  - Posting program information on site including observation data analysis.
  - Providing a summary of safe and at-risk observations during daily Safety Meetings.
  - Providing feedback to employees that unsafe observations have been corrected.
  - Soliciting recommendations for program improvements with staff.
- The Health and Safety Network will be responsible for providing these means of communication.

5.2. Training:

5.2.1 TRC employees will undergo BBS orientation training as part of their employee orientation. It is anticipated that eventually all employees will participate in the BBS Program. Employees performing observations will undergo additional training regarding the observing process. This training will be offered by the Health and Safety Network, Project Manager, or other designated Health and Safety staff.

5.3. Audits and Inspections:

5.3.1 Periodic audits of BBS procedure execution will be conducted by the Health and Safety Network. These audits shall be documented in the project files and deficiencies (i.e., participation levels) shall have timely corrective action measures defined. The auditor will be responsible for ensuring that corrective measures are met within the established timeframe, and must report any non-compliance to the Project Manager for immediate follow-up including, but not limited to, disciplinary action for the affected individuals as outlined in TRC's Employee Handbook.

5.4. Documentation:

5.4.1 All SOFs, SOF Data Tracking Forms shall be maintained by the Health and Safety Network. This data will be transmitted by the Health and Safety Network to the employee(s) tasked with gathering company BBS data.

6. REFERENCES/RELATED DOCUMENTATION

TRC Forms/Procedures

Appendix A - Safety Observation Form (SOF)

CP002 – Risk Analysis/Site-Specific Health and Safety Program

APPENDIX A

SAFETY OBSERVATION FORM

TRC SAFETY OBSERVATION FORM

Revised January 2014

Location/Project Name: ______________________ **Date:** ____________

Observer Name: ______________________

Observee Name: ______________________ **Time:** ____________

Task Observed

Description of Task Observed and Background Information

Positive Comments

Conclusions / Why the Questionable Items Occurred?

Feedback Session Conducted By: ______________________ **Date:** ____________

Name of Observee's Supervisor: ______________________ **Time:** ____________

At-Risk Observations/Root Cause Analysis

Personal Factor:
(1) Lack of skill or knowledge
(2) Correct way takes more time/requires more effort
(3) Shortcutting standard procedures is rewarded or appreciated
(4) In past, did not follow procedures or acceptable practices and no incident occurred

Job Factor:
(5) Lack of or inadequate operational procedures or work standards
(6) Inadequate communication of expectations or work standards
(7) Inadequate tools or equipment

At-Risk Observation #	Root Cause Analysis #	Solution(s) To Prevent Potential Incident from Occurring	Person Responsible	Agreed Due Date	Date Completed

Results of Verification (were solutions done?) and Validation (were solutions effective?)

Reviewed by (PM/Supervisor): ______________________ **Date:** ____________

Approved by (Practice Safety Leader): ______________________ **Date:** ____________

TRC SAFETY OBSERVATION FORM

Revised January 2014

PERSONAL PROTECTIVE EQUIPMENT	Safe	At-Risk	Comments
1. Hearing Protection (e.g., Ear Plugs)			
2. Head Protection (e.g., Hard Hat)			
3. ANSI Rated Eye Protection (e.g., Safety Glasses)			
4. Hand Protection (e.g., Kevlar Gloves)			
5. Foot Protection (e.g., Safety Shoes)			
6. Respiratory Protection			
7. Fall Protection Inspected (e.g., Harness)			
8. ANSI Rated Reflective Vest/High Visibility Clothing			
9. Other (Specify)			
BODY USE AND POSITIONING	**Safe**	**At-Risk**	**Comments**
10. Correct Body Use and Positioning When Lifting/Pushing/Pulling			
11. Pinch Points/Moving Equipment - Hands/Body Clear			
12. Mounts/Dismounts Using 3-Points of Contact			
13. Other (Specify)			
WORK ENVIRONMENT	**Safe**	**At-Risk**	**Comments**
14. Work/Walk Surface Free of Obstructions (e.g., Tripping Hazards)			
15. Housekeeping/Storage			
16. Defined and Secured (e.g., warning devices, barricades, cones, flags)			
17. Suspended Load, Swing Radius & Lift Area is Barricaded			
18. Safety Shutdown Devices			
19. Proper Storage & Labeling /Disposal of Sample & Waste Materials			
20. Cylinders Stored Upright, Secured, & Caps in Place			
21. Manhole/vault Inspected for Hazards			
22. Other (Specify)			
OPERATING PROCEDURES	**Safe**	**At-Risk**	**Comments**
23. Job Planning (HASP reviewed, JSAs, etc.)			
24. Fire Extinguishers Accessible and Inspections Current			
25. Work Permit/Authorization to Work (Hot, Cold, LOTO, Confined Space)			
26. JSA Reviewed & Followed			
27. Hazard Assessment - Hazard Hunt			
28. Interfaces with Other Functions (awareness with other personnel on site)			
29. Operators Looking Behind Prior to Backing Up			
30. Operators Wearing Seat Belts While Operating Equipment			
31. Subsurface Structures Identified			
32. Proper Trench Protective Equipment in Place			
33. Adequate Egress Is Available for Excavation & Trench (within 25 ft. if depth is <4 ft.)			
34. All Materials Set Back at Least 2 Feet From Edge of Trench/Excavation			
35. Other (Specify)			
TOOLS/EQUIPMENT	**Safe**	**At-Risk**	**Comments**
36. Hand Tools (Proper Equipment Selection, Condition, and Use)			
37. Power Tools (Proper Equipment Selection, Condition, and Use)			
38. Equipment, Including Heavy (Proper Equipment Selection, Condition, and Use)			
39. Hoses Inspected			
40. Required Monitoring Equipment Calibrated & Used			
41. Ladders Set up Correctly & Inspected			
42. Right Tools for the Job are Available and in Good Condition - No Fixed Open Blade Knives (FOBKs)			
43. Other (Specify)			
Total #	0	0	

1. PURPOSE

The purpose of this compliance program is to set forth the process that must be utilized to evaluate an employee's fitness for duty when an employee is:

- Exhibiting observable behavior that impacts the effective and safe performance of his/her duties,
- Posing a serious safety and/or security threat to self or others,
- Expressing concern or requests job accommodation,
- Returning-to-work (FMLA, ADA, STD, LTD, WC injury/illness),
- Participating in a medical surveillance exam, or
- Participating in a post job offer (pre-employment) physical exam.

The application of this program is not intended as a substitute for TRC's policies or procedures related to performance or behavioral problems, or as a substitute for discipline. Supervisors should continue to address and implement appropriate corrective or disciplinary actions.

2. SCOPE

This policy applies to all TRC employees. This policy does not apply to employees with short-term, infectious/communicable diseases (e.g., flu, colds).

3. DEFINITIONS

ADA – Americans with Disabilities Act.

Coordinating Team – The appropriate parties responsible for coordinating and facilitating the fitness for duty evaluation. The Coordinating Team may include the employee's supervisor, Human Resources Representative, the Office Safety Coordinator (OSC), and others that may be necessary to determine the appropriate course of action.

Disability – Defined under the American with Disabilities Act (ADA) to include any individual who has physical or mental impairment that substantially limits or more major life activity; or has a record of such an impairment; or is regarded as having such an impairment.

Employee Assistance Program (EAP) – A program/employee benefit offered by TRC that provides comprehensive, confidential, employee assistance services (such as short term counseling, assessment, and referral services) that might adversely impact their job performance, health, and well-being to covered TRC employees and their families.

Fit for Duty (FFD) – To perform the duties of the job, in accordance with the essential functions of the job, in a safe, and productive manner.

FMLA – Family and Medical Leave Act.

LTD – Long term disability insurance.

Medical Record – Any document containing medical information about an employee is considered a medical record and is regarded as confidential.

STD – Short term disability insurance.

Substance Abuse Professional (SAP) – This is a person who evaluates employees who have violated a DOT drug and alcohol program regulation and makes recommendations concerning education, treatment, follow-up testing, and aftercare.

WC – Workers compensation insurance.

4. POLICY

4.1 TRC is committed to maintaining a safe and productive workplace, and it therefore requires that every employee report to work fit to perform their job duties in a safe, secure, productive, and effective manner, and remain able to do so throughout the entire time they are working. Employees who are not fit for duty may present a safety hazard to themselves, to other employees, or the Company. For purpose of this program, "fitness for duty" refers to the readiness of an employee to perform the essential functions of the job.

4.2 In partnership with WorkCare, Inc., Aetna Disability, Sargent and Associates, and Ceridian Lifeworks (EAP and SAP), our third party administrators (TPA), TRC provides a full range of pre-placement, annual, and exit physicals for applicable employees, in compliance with the Occupational Health and Safety Administration (OSHA) 29 CFR Part 1910.120 Hazardous Waste Operations standard, DOT physicals, in compliance with the Federal Motor Carrier Safety Administration (FMCSA) 49 CFR 391.41; and return to work evaluations, in compliance with the Americans with Disabilities Act (ADA). This program compliments other health and safety programs, such as training and/or use of personal protective equipment.

4.3 TRC's third party administrators are the central repository for all TRC's medical records and maintain them in accordance with applicable OSHA Regulations and Health Insurance Portability and Accountability Act (HIPAA). The contents of all records are kept confidential at all times. In addition to these measures, TRC's TPA's adhere to HIPAA guidelines that protect the privacy of medical records through administrative, technological and physical safeguards.

4.4 TRC is committed to equal employment opportunity, and it prohibits discrimination against qualified individuals with disabilities. This program is to be construed consistent with that commitment and in compliance with applicable law, including the Americans with Disabilities Act.

4.5 TRC will provide reasonable accommodations for otherwise qualified disabled individuals in accordance with the Americans with Disabilities Act of 1993, and as amended.

4.6 TRC will communicate this program to new employees during orientation, via email to notify them of the new program, and it will be accessible on TRC's intranet site TRCNET.

5. RESPONSIBILITIES

5.1 The National Safety Director, or his/her designee, is responsible for facilitating the return to work process for employees with work-related injuries.

5.2 Human Resources is responsible for coordinating fitness for duty examinations for employees and communicating the results to Supervisors.

5.3 Supervisors are responsibilities for the following:

- Observing the attendance, performance, and behavior of the employees they supervise;
- Determine the physical requirements for their respective areas of responsibilities, which includes both field and office work;
- Communicate the physical requirements for each job, to the employee through job descriptions and field project plans (i.e., Health and Safety Plans);
- Following this program when presented with circumstances or knowledge that indicate that an employee may be unfit for duty; and
- Maintaining confidentiality of medical records and/or knowledge of medical information.

5.4 Coordinating Team Members are responsible for the following:

- Ensuring that the appropriate departments have been consulted;
- Soliciting information from the supervisor regarding employee behaviors or performance, and from the employee regarding any relevant previous medical or psychological treatment information;
- Identifying who will conduct the fitness for duty evaluation;
- Receiving the results of the fitness for duty evaluation and ensuring that the results have been communicated to the employee;

- Implementing any recommendations proposed by the fitness for duty evaluation;
- Communicating with the employee as to their rights, responsibilities and employment status; and
- Maintain confidentiality of medical records and/or knowledge of medical information.

5.5 Employees are responsible for the following:

- Managing their health in a manner that allows them to safely perform their job responsibilities;
- Reporting to work fit for duty and perform their job responsibilities in a safe, secure, productive, and effective manner during the entire time they are working;
- Adhering to any temporary or permanent physical restrictions prescribed by a medical provider.
- Notifying their supervisors when they are not fit for duty;
- Notifying a supervisor when they observe a coworker acting in a manner that indicates the coworker may be unfit for duty. If the supervisor's behavior is the focus of concern, an employee may inform senior management, an Office Safety Coordinator (OSC), a member of Human Resources team, or call the Employee Assistance Program (EAP) for further guidance at 877-543-5153; and
- Complying with this policy and any authorized request to submit to an evaluation.

6. PROCEDURE FOR A FIT FOR DUTY EXAM OR WORKPLACE ACCOMMODATION REQUEST

6.1 Employee Self -Referral

- Upon receipt of a workplace accommodation from the employee, the HR Representative will coordinate this request with the employee's supervisor.
- The supervisor and HR Representative will make a determination on the accommodation request.
- The supervisor and HR Representative will notify the employee of the outcome.

6.2 Manager Referral

- Upon receipt of a fit for duty referral, the supervisor will meet with the Coordinating Team to gain a clear understanding of the behaviors and circumstances that have raised questions about the employee's fitness for duty.
- Documentation must be submitted to Human Resources the next business day.

- A member of the Coordinating Team shall also notify the employee of the opportunity to provide any relevant previous medical or psychological treatment information.
- The Coordinating Team shall determine the appropriateness of fitness for duty testing within a reasonable time after notification from the supervisor, usually within three business days.
- In partnership with TPA's, the Coordinating Team will determine if the employee should continue working in a non-safety sensitive role or if employment should be suspended until further notice.

6.3 Results of the Evaluation

- The results of fitness for duty evaluations performed by qualified, licensed health care professionals shall be presumed to be valid. Results of the evaluation will be received by the Coordinating Team. The employee shall be notified of the results of the fit for duty evaluation.
- A member of the Coordinating Team will communicate to the employee's supervisor whether the employee may return to work.
- After an evaluation, information given to the employee's supervisor shall be limited to whether the employee may:
- Return to full duty;
- Return to conditional limited duty;
- Not return to full duty, in which case the employee will be referred to the HR Representative for a benefits discussion.

7. RETURN TO WORK

7.1 If the employee has cooperated in the fit for duty examination and is in compliance with recommendations from medical, psychological, and/or chemical dependency treatment (including continuing care or aftercare, and random drug and alcohol testing if appropriate), the employee may be returned to the job provided appropriate discipline, if warranted, has been administered, and subject to all other Company policies. Conditions for return to work will be determined by the supervisor and the Coordinating Team in consultation with EAP, Occupational Health, and or insurance providers.

7.2 If an employee sustains a work related injury that could result in permanent or temporary physical limitations, the employee must be evaluated by a licensed health care provider to determine if the employee can safely perform their job. This process will coordinated between the employee's supervisor, the National Safety Director, Human Resources, and the health care provider, which may include TRC's contract occupational health care advisor WorkCare.

- At this time, the National Safety Director, or TRC's contract occupational health care provider will inform the injured employee and the employee's treating health care provider of TRC's desire to accommodate temporary work restrictions.
- On a case by case basis, the National Safety Director and the injured employee's supervisor will evaluate the availability of temporary modified work for employees with temporary restrictions. When possible, temporary modified work that is in accordance with the employee's physical abilities, will be offered to employees.
- TRC's Human Resources department, in consultation with the employee's supervisor, will manage work assignments and accommodations for employees who have, or develop permanent physical limitations that could affect their ability to perform their job. TRC will provide reasonable accommodations to qualified employees with disabilities in accordance with applicable law. Because each case is different, accommodations will be evaluated on a case by case basis.

7.3 Employees will not be expected to perform tasks that exceed employees' physical capabilities.

8. RECORDS

Records of fitness for duty evaluations and or medical restrictions that contain medical information will be treated as confidential medical records. This information may be shared only on a need to know basis. Employees may obtain a copy of their medical records upon written request. Incident investigation records will be maintained per CP019 Incident Investigation and Lessons Learned Program.

9. APPENDICES

A – Fitness for Duty Observation Check List

Appendix A
Fitness For Duty Checklist

(This observation checklist can be used to record demonstrated behavior).

Walking (Check One)

☐ **Stumbling**
☐ **Staggering**
☐ **Falling**
☐ **Swaying**
☐ **Unsteady**
☐ **Holding on**
☐ **Unable to**

Standing (Check One)

☐ **Swaying**
☐ **Unable to stand**
☐ **Feet wide apart**
☐ **Staggering**
☐ **Sagging at knees**

Movements (Check One)

☐ **Fumbling**
☐ **Jerky**
☐ **Slow**
☐ **Normal**
☐ **Nervous**
☐ **Hyperactive**

Speech (Check One)

☐ **Shouting**
☐ **Silent**
☐ **Whispering**
☐ **Slow**
☐ **Rambling**
☐ **Mute**
☐ **Slurred**
☐ **Slobbering**
☐ **Incoherent**

Demeanor (Check One)

☐ **Cooperative**
☐ **Polite**
☐ **Calm**
☐ **Crying**
☐ **Silent**
☐ **Talkative**
☐ **Excited**
☐ **Sarcastic**
☐ **Fighting**

Face (Check One)

☐ **Flushed**
☐ **Pale**
☐ **Sweaty**

Eyes (Check One)

☐ **Bloodshot**
☐ **Watery**
☐ **Dilated**
☐ **Glassy**
☐ **Droopy**
☐ **Closed**

Breath (Check One)

☐ **Alcoholic odor**
☐ **Faint alcoholic odor**
☐ **No alcoholic odor**

Actions (Check One)

☐ **Resisting communication**
☐ **Fighting**
☐ **Threating**
☐ **Calm**
☐ **Drowsy**
☐ **Profanity**
☐ **Hyperactive**
☐ **Hostile**
☐ **Erratic**

Appearance (Check One)

☐ **Unruly**
☐ **Messy**
☐ **Dirty**
☐ **Partially dressed**
☐ **Bodily excrement stains**

Clothing (Check One)

☐ **Stains on clothing**
☐ **Neat**
☐ **Having odor**

1. PURPOSE

The purpose of this procedure is to outline the requirements and process for investigating, recording and reporting work-related incidents that occur in the field or in TRC offices.

2. SCOPE

This procedure applies to field work performed or managed by TRC personnel and office work performed in locations owned or leased by TRC.

3. DEFINITIONS

Incident: A work-related event in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.

OSHA: Occupational Safety and Health Administration.

Corrective Action: An action taken after an incident to eliminate or reduce the risk of a similar incident occurring.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Maintaining TRC's incident investigation process and communicating the process to TRC personnel.
- Communicating work related incident information, including the Root Cause, Corrective Actions and Lessons Learned to TRC personnel.
- Ensuring Corrective Actions are implemented and verified.

4.2 TRC's Legal Department is responsible for facilitating the communication with regulatory agencies (i.e., Occupational Safety and Health Administration (OSHA)) for incidents that require notification.

4.3 Project Managers are responsible for the following:

- Initiating and participating in the incident investigation process for incidents occurring on project sites.
- Communicating with clients and affected Subcontractors on incidents that occur on project sites.

4.4 Supervisors are responsible for the following:

- Facilitating the incident investigation process for their direct reports.
- Assisting Project Managers with the incident investigation process as it applies to their direct reports.
- Assisting the National Safety Director with investigating incidents, determining the Root Cause and Corrective Actions.

4.5 The Executive Safety Council is responsible for evaluating incident trends to determine if improvement programs are needed.

4.6 The Corporate Safety Compliance Manager is responsible for assisting the National Safety Director with evaluating the compliance of office and field work performed or managed by TRC personnel.

4.7 Office Safety Coordinators are responsible for assisting the National Safety Director and Supervision with investigation of work related incidents.

4.8 Employees are responsible for the following:

- Reporting early signs and symptoms of work related injuries and illnesses to Supervision or a member of TRC's Health and Safety Network.
- Reporting all work related incidents, no matter how severe, to Supervision or a member of TRC's Health and Safety Network immediately.
- Participating in incident investigations to help identify the Root Cause and Corrective Action(s).

5. PROCEDURE

5.1 Providing medical attention to the injured person always takes precedent in the incident investigation process.

5.2 Upon receiving notification of a work related incident, the employee's direct Supervisor will initiate the incident investigation process in accordance with CP019 – TRC Incident Response and Lessons Learned Program.

- Project Managers will initiate the incident investigation process for incidents occurring on field work.

5.3 Project Managers and Supervisors will report work related incidents to the National Safety Director in a timely manner.

5.4 The National Safety Director will facilitate the evaluation of operational controls that were associated with the incident to determine if modifications to operational controls or the hazard identification process are necessary to prevent reoccurrence.

5.5 The National Safety Director will facilitate the development of Lessons Learned for injuries and illnesses that meet OSHA's recordkeeping criteria and serious incidents that could have resulted in an injury or illness.

6. RECORDS

Completed Project/Field Safety Audit Forms

Completed Office Safety Checklists

Complete Incident Investigation Reports

Lessons Learned Communications

7. RELATED DOCUMENTATION

CP019 – TRC Incident Response and Lessons Learned Program

1. PURPOSE

The purpose of this compliance program is to establish the responsibilities and requirements for protect employees from the transmission of human bloodborne pathogens through occupational exposure to human blood and other potentially infectious materials while providing first aid treatment to an injured coworker.

2. SCOPE

This procedure applies to TRC employees (full-time, part-time, and contracted) who work in a TRC office or field job site.

3. DEFINITIONS

Automated external defibrillator (AED): A portable device that automatically analyzes the heart rhythm and, if it detects a problem that may respond to an electrical shock, permits a shock to be delivered to restore a normal heart rhythm.

Bloodborne Pathogens: Means pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV) and human immunodeficiency virus (HIV).

Contaminated Sharps*:* means any contaminated object that can penetrate the skin including, but not limited to, needles, scalpels, broken glass, broken capillary tubes, and exposed ends of dental wires.

Occupational Exposure: means that during the course of an employee's job duties, there is the potential for contact with blood, body fluids, body tissue, etc., through their skin, eyes, mouth, or mucous membranes.

Exposure Incident: Means an incident in which a person's eye, mouth, other mucous membrane, or broken skin comes into contact with a potentially infectious material such as, blood, body fluids, body tissue, etc. This can occur through bites, cuts, abrasions, contact, etc.

Infectious Material: Means any blood, body fluid or body tissue that is infected with a bloodborne pathogen.

Regulated Waste: means liquid or semi-liquid blood or other potentially infectious materials; contaminated items (e.g., bandages or clothing) that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling; and contaminated sharps.

Universal Precautions: means the practice of considering all potentially infectious material to be infectious and taking precautions without regard to source or the results of screening tests.

- All blood and other potentially infectious materials are handled as if known to be infectious for Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV) and other bloodborne pathogens.
- All employees identified in the Exposure Determination must routinely use appropriate barrier precautions to prevent skin and mucous membrane exposure when contact with blood or other potentially infectious material is anticipated.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Establishing this compliance program and communicating the requirements to the Office Safety Coordinators, Supervisors, and Project Managers.
- Reviewing this compliance program at least annually and revising the program as necessary to verify it remains effective.

4.2 Project Managers are responsible for the following:

- Confirming that first aid treatment is available (within a four minute response time) to field employees who could reasonably be expected to sustain a work-related injury that requires treatment. Examples such work include: working at construction or demolition sites, working over or near water (pond, river, lake, etc.), working at heights, etc.
  - o The names and contact numbers of project employees working at the site who are current with first aid training shall be listed in the site-specific HASP. Additionally, directions to the nearest medical facility should be listed in the HASP.
- Confirming that at least one person trained in CPR is present when the following types of work are performed.
  - o Permit Required Confined Space Entry,
  - o Diving,
  - o Electric Power Generation, Transmission, and Distribution
  - o Construction, Power Transmission and Distribution
- Determining the proper type of first aid kit for each project, based on the guidance in Appendix A.
- Confirming that first aid kits being sent to field project sites are inspected to ensure the proper supplies are present and not expired.

- Designating a project employee to perform weekly inspections of first aid supplies at construction sites.
- Identifying the closest emergency medical provider to the project site and listing the address and phone number in the site-specific HASP.

4.3 Office Safety Coordinators are responsible for the following:

- Assist with ordering first aid supplies for offices and field projects, and periodically inspecting first aid supplies to confirm they're available and not expired.
- Coordinating AED inspections at TRC offices (where they are installed).
- Coordinating first aid training for TRC personnel desire to complete the training.

4.4 TRC employees trained in first aid are responsible for the following:

- At their discretion, act as a Good Samaritan to provide first aid employees with medical emergencies. The extent to which employees respond to an incident, shall be commensurate with their training and experience.
- Staying current with first aid training and communicating training status to Office Safety Coordinators and supervisor.
- Use universal precautions in accordance with training to prevent contact with blood or other potentially infectious material.
- Report exposure incidents involving potentially infectious material to the supervisor and the National Safety Director immediately.
- Maintaining a working cellular phone while onsite that can be used to contact the nearest emergency medical provider. The phone number for the emergency medical provider will be listed in the Site-Specific HASP.

5. PROCEDURES

5.1 First Aid

- When field work involves tasks that could reasonably result in injuries that could require first aid treatment, and the nearest emergency medical response (i.e., ambulance, fire department) is more than four minutes away, the Project Manager shall verify that at least one TRC employee is current with first aid and CPR training.
- TRC employees working at the jobsite who are current with first aid training may voluntarily provide first aid treatment, including CPR and AED to and injured employee in accordance with their training.

- Field employees should contact emergency medical services for serious injuries by using their cellular telephone.
- Should 911 not be available, the contact numbers of physicians, hospitals, or ambulances shall be researched and posted.
- All TRC employees shall also contact WorkCare (**888-449-7787**) for work-related injuries and illnesses.
- A valid certificate in first aid training must be obtained from the American Red Cross, or equivalent training must be available for review.

5.2 Exposure Determination

- The following group of employees who perform duties or tasks have been determined to have a reasonably anticipated occupational exposure to blood or other potentially infectious material. This determination has been made without regard to the use of personal protective equipment.
  - Employees perform who provide first aid treatment and perform cardiopulmonary resuscitation (CPR).

5.3 Work Practice Controls

- All potentially infectious materials, as defined in section 3.0, shall be handled as infectious, regardless of the source of the material.
- Employees who perform first aid treatment or administer CPR must wear latex or other water-resistant gloves prior to contacting blood or other potentially infectious material.
- Safety glasses with side shields must be worn during all work with potentially infectious material.
- If regulated waste is generated, the waste must be placed in a red bag labeled "biohazard." Note: Used Band-Aids are typically not considered regulated waste.
- Eating, drinking, smoking, applying cosmetics or lip balm, and handling contact lenses are prohibited while performing first aid or CPR.
- For emergency response, place a physical barrier between the provider and the blood or body fluids of the victim being treated. Examples of appropriate barriers include gloves, clean cloth, bandages and rescue blankets.
- For CPR or rescue breathing, use a face mask as a barrier between rescuer and victim.

- Employees shall wash their hands with soap and water immediately after providing medical emergency response activities. Handwashing facilities should be readily accessible and identified. Should handwashing facilities not be accessible, appropriate antiseptic hand cleanser in conjunction with clean cloth/paper towels or antiseptic towelettes. Hand should be washed with soap and running water as soon as feasible.

5.4 Handling Sharps

- The potential for transmission of infection is greatest when handling needles or other sharps that may be contaminated with infectious material.
- Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed from syringe barrels by hand.
- Contaminated sharps shall be disposed of in rigid containers labeled as biohazard.

5.5 Housekeeping

- Any of the following disinfectants may be used to disinfect surfaces that have been exposed to potentially infectious substances:
  - A freshly made 10% solution of household bleach in water
  - Solution Amphyl (commercially available disinfectant)
  - Solution Lysol (commercially available disinfectant)
- All rags, paper towels or blood absorbing agents used to clean up blood or potentially infectious material should be placed in a leak-proof waste container or sealed bag and labeled with the appropriate biohazard labels.
- After an area has been cleaned with rags or blood absorbing agents, a bleach solution or an EPA registered germicide should be used as a final clean up.
- All contaminated work surfaces should be decontaminated as soon as feasible.
- Disposal of bio-hazardous waste will be performed in accordance with applicable regulatory requirements.

5.6 Hepatitis B Vaccination and Post-Exposure Evaluation and Follow-up

- Hepatitis-B vaccination is available to TRC employees who complete first aid/CPR training and offer to voluntarily respond to first aid injuries in the workplace. The vaccine will be offered at no cost within 10 working days of initial assignment to all employees who have occupational exposure, unless the employee has previously received the complete hepatitis-B vaccination series, or antibody testing has revealed that the employee is immune, or the vaccine is contraindicated for medical reasons, or the employee declines the vaccination.

- If an employee initially declines the hepatitis-B vaccination but at a later date decides to accept the vaccination, the vaccination will be provided.
- Employees who decline the vaccination must sign a declination statement. The signed statement will be maintained with medical records by the Human Resources Department.
- All exposures to potentially infected agents must be reported immediately to the employee's supervisor and to the National Safety Director.

  Exposures include the following:
  - Accidental puncture or cut with a contaminated syringe or other sharp object.
  - Contact between skin or mucus membranes and potentially infectious material.
- Following a report of an exposure incident, the employee is entitled to a confidential medical evaluation and follow-up.
- Exposure incidents involving potentially infectious materials shall be reported, and managed as privacy cases, according to CP019 Incident Response and Lessons Learned.
- The source individual's blood shall be tested as soon as feasible and after consent is obtained in order to determine HBV and HIV infectivity. If consent is not obtained, this will be noted in the affected employee's medical record. When law does not require the source individual's consent, the source individual's blood, if available, shall be tested and the results documented and managed as confidential.
- Results of the source individual's testing shall be made available to the exposed employee, and the employee shall be informed of applicable laws and regulations concerning disclosure of the identity and infectious status of the source individual.

5.7 First aid supplies

- Office Safety Coordinators will select appropriate first aid kits for office locations and TRC fleet vehicles.
- Emergency eyewash facilities shall be provided where employees are exposed to corrosive chemicals.
- Project Managers shall identify the number and type of first aid kits based on the guidance in Appendix A. Project Managers should consider the risks and task load of the work environment and the potential severity and likelihood of occurrence of an injury. Since each workplace is unique, additional first aid kit components should be selected in addition to the basic components to address these hazards.
- First aid kits should contain bloodborne pathogen related PPE and a biohazard waste bag for exposure control and will be provided at no cost to the employee. PPE includes the following:

- CPR or rescue breathing masks.
- Latex, Nitrile or vinyl disposable gloves.

5.8 Training and Recordkeeping

- Employees who elect to complete first aid training will be provided training on bloodborne pathogens and methods used to prevent exposure to potentially contaminated material. This training will be provided upon initial assignment and annually thereafter. Employees who receive the required training will have access to this compliance program through TRCNET.
- Employees who volunteer to provide first aid treatment, perform CPR or use and AED on an injured or ill person in the workplace should be current appropriate training. The frequency of this training is determined by the agency providing the training (e.g., Red Cross).
- Training records will be maintained for at least 3 years from the date on which the training occurred.
- Employee exposure and medical records shall be kept for the duration of employment plus 30 years. Exposure and medical records will associated with this program shall be kept confidential and will not be disclosed or reported to anyone within or outside of the Company without the express written consent of the employee except as required by law.
- First/CPR/AED training records shall include the certificate from the issuing agency and be available for review upon request.

6. REFERENCES/RELATED DOCUMENTATION

29 CFR 1910.151 Medical Services and First Aid

29 CFR 1910.1030 Bloodborne Pathogens

29 CFR 1926.50 Medical Services and First Aid

ANSI 308.1-2015 – Minimum Requirements for Workplace First Aid Kits

CP019 - TRC Incident Response and Lessons Learned Program

7. APPENDICES

A – Recommended Contents for First Aid Kits

Appendix A
Recommended Contents for First Aid Kits

The following table is taken from the ANSI 308.1-2015 standard and sets forth the minimally acceptable number and type of first aid supplies for First Aid kits required under this program. **Class A** kits are designed to deal with the most common types of workplace injuries. **Class B** kits are designed to deal with a broader range and quantity of supplies to deal with injuries in more complex or high-risk environments.

ANSI Z308.1–2015, TABLE 1: CLASSES OF FIRST AID KITS & REQUIRED SUPPLIES

First Aid Supply	Minimum Quantity		Minimum Size or Volume	
	Class A Kits	Class B Kits	(U.S.)	(Metric)
Adhesive Bandage	16	50	1 x 3 in.	2.5 x 7.5cm
Adhesive Tape	1	2	2.5 yd. (total)	2.3m
Antibiotic Application	10	25	1/57 oz.	0.5g
Antiseptic	10	50	1/57 oz	0.5g
Breathing Barrier	1	1		
Burn Dressing (Gel Soaked)	1	2	4 x 4 in.	10 x 10cm
Burn Treatment	10	25	1/32 oz.	0.9g
Cold Pack	1	2	4 x 5 in.	10 x 12.5cm
Eye Covering (with Means of Attachment)	2	2	2.9 sq. in.	19 sq. cm
Eye/Skin Wash	1 fl. oz. total			29.6mL
		4 fl. oz. total		118.3mL
First Aid Guide	1	1	N/A	N/A
Hand Sanitizer	6	10	1/32 oz	0.9g
Medical Exam Gloves	2 pair	4 pair	N/A	N/A
Roller Bandage (2 inch)	1	2	2 in. x 4 yd.	5cm x 3.66m
Roller Bandage (4 inch)	0	1	4 in. x 4 yd.	10cm x 3.66m
Scissors	1	1	N/A	N/A
Splint	0	1	4.0 x 24 in.	10.2 x 61cm
Sterile Pad	2	4	3 x 3 in.	7.5 x 7.5cm
Tourniquet	0	1	1 in. (width)	2.5cm (width)
Trauma Pad	2	4	5 x 9 in.	12.7 x 22.9cm
Triangular Bandage	1	2	40 x 40 x 56 in.	101 x 101 x 142cm

First aid kit containers are classified by portability, the ability to be mounted, resistance to water, and corrosion and impact resistance.

Type I: Intended for use in stationary, indoor applications where kit contents have minimal potential for damage. These kits are not intended to be portable and should have a means for mounting in a fixed position. Some applications for Type I first aid kits are general indoor use, office use or use in a light manufacturing facility. First aid cabinets would fall in this classification.

Type II: Intended for portable use in indoor applications where the potential for damage to kit supplies due to environmental factors and rough handling is minimal. Some applications for Type II first aid kits are general indoor use, or use in office or manufacturing environments.

Type III: Intended for portable use in mobile indoor and/or outdoor settings where the potential for damage of kit supplies due to environment is not probable. These kits should have the means to be mounted in a fixed position and have a water-resistant seal. Typical applications are general indoor use and sheltered outdoor use.

Type IV: Intended for portable use in mobile industries and/or outdoor settings where the potential for damage to kit supplies due to environmental factors and rough handling is significant. These kits must have a means to be mounted in a fixed position and must be corrosion, moisture and impact resistant (meet the performance requirements of ANSI/ISA Z308.1-2015 Section 5.2.5). Typical applications for Type IV first aid kits include the transportation, utility and construction industries, and the armed forces.

1 PURPOSE

This compliance program outlines the responsibilities and process for investigating work-related incidents, developing corrective actions, and communicating lessons learned throughout the organization. In conjunction to what is written in this compliance program, TRC will follow the regulations of 29CFR 1904.39: Recording and Reporting Occupational Injuries and Illness.

2 SCOPE

This program applies to all TRC personnel.

3 DEFINITIONS

Environmental Incident: An unplanned event that caused, or could likely have caused, a negative impact on the environment.

Illness: Unhealthy condition; poor health; indisposition; sickness.

Injury: Wound or trauma; damage inflicted on the body by an external force.

Near Miss: A situation or condition that has a potential for an incident to occur. No property was damaged and no injury or illness was sustained, but where given a change in time or position, an environmental incident, property damage or personal injury could have occurred.

Nonconformance: A deviation from applicable legal and other requirements, which include TRC's Health and Safety Management System and client expectations.

Safe Catch: A near miss or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries.

Safety Incident: A work-related event in which an injury or illness occurred or could have likely occurred. Subcategories of incidents include near misses and safe catches.

Severe Injury: the inpatient hospitalization of one or more employees, an amputation, or loss of an eye.

4 ROLES AND RESPONSIBILITIES

4.1 The National Safety Director is responsible for the following:

- Communicate this program and the requirements to the entire company.

- Lead or facilitate investigations for incidents and safety related non-conformances.
- Facilitate the corrective action process with the affected employees.
- Assist with developing and communicating the Lessons Learned Report to the entire company.
- Coordinate audits of field work in accordance with TRC's Health and Safety Management System to confirm that the corrective actions were implemented and are effectively controlling the hazard(s).

4.2 The Corporate Safety Manager is responsible for the following:

- Assisting with incident investigations to identify corrective actions.
- Assist members of TRC's Health and Safety Network with the development of Lessons Learned Report.

4.3 Health and Safety Network is responsible for the following:

- Assisting in incident investigations.
- Development of Lessons Learned Reports.
- Communicating the Lessons Learned Report in safety meetings.

4.4 Project Managers are responsible for the following:

- Communicate with National Safety Director and Corporate Safety Managers when an incident occurs.
- Initiating and assisting with investigating incidents and non-conformances.
- Assisting with developing corrective actions.
- Assist the Health and Safety Network with the dissemination of the Lessons Learned Report.

4.5 Employees are responsible for the following:

- Participating in incident investigation and development of corrective actions.
- Reviewing lessons learned and supporting corrective actions.

5 INCIDENT RESPONSE PROCESS

TRC employees must report all incidents and potential injuries to their supervisor immediately.

5.1 Emergency Procedures:

In the event of an emergency:

- Stop work and REMAIN CALM.
- Move personnel to a safe location.
- For life threatening injuries and medical emergencies call 911 or go to the closest emergency room.
- If serious injury or life-threatening condition exists, call 911. Clearly describe the location, injury and conditions to the dispatcher. Designate a person to direct emergency equipment to the injured person.
- Address medical emergencies and apply first aid, if necessary. Contact WorkCare for all injuries, even when symptoms are minor.
- Contain physical hazards.
  - Act only if hazard is minimal and you are trained to deal with the situation. Otherwise evacuate and wait for emergency services to arrive.
- Do not resume work until Project Manager/Supervisor has determined it safe to do so and appropriate corrective actions have been implemented to prevent the incident from occurring again.

5.2 Non-Emergency Procedures:

In the event of a non-emergency injury or incident:

- Employees:
  - Stop work immediately;
  - Contact Project Manager/Supervisor; and
  - Contact WorkCare for all injuries, even when symptoms are minor.
- Project Manager/Supervisor:
  - Immediately notify the TRC National Safety Director and to the injured employee's direct supervisor.

- o Work with employee(s) to mitigate hazard(s) which caused incident and institute corrective actions.

5.3 Incident Reporting to OSHA

- Fatality
  - o The Occupational Safety and Health Administration (OSHA) is to be contacted within eight hours after the fatality of any employee because of a work-related incident.
- Severe Injury
  - o OSHA is to be contacted within 24 hours after a severe injury to any employee because of a work-related incident.
- Methods of Contacting OSHA
  - o By telephone or in person to the OSHA Area Office that is nearest to the site of the incident.
  - o By telephone to the OSHA toll free central telephone number, 1-800-321-OSHA (6742).
  - o By electronic submission using the reporting application located on OSHA's public website at www.osha.gov.

6 INCIDENT INVESTIGATION

All work-related incidents shall be investigated in a timely manner. Incidents that resulted in injury or illness, including first aid and early stage symptoms (i.e., sore muscle, rash, etc.) must be documented.

The affected Supervisor is required to complete the TRC Incident Report Form within 24 hours of the reported accident and forward to the National Safety Director.

As part of the incident investigation, it will be necessary to interview the injured or affected employee along with any other employees who may have been involved or who witnessed the incident. Remember that you are working to know the facts of the situation; "fault" is not a concern. Below are some guidelines to assist in conducting the interview:

1. Conduct interview(s) as soon as possible after the incident.
2. Focus on interviewing person(s) most directly involved with the incident.
3. Be respectful of the interviewee's physical and emotional state; be sympathetic if the person has suffered an injury.

6.1 Initiating an Interview:

- Introduce yourself and ask the person if they can help you determine what happened.

- If possible, conduct the interview in a private location.
- Put the interviewee at ease by:
    - Explaining that getting the facts may help prevent a recurrence;
    - Explaining that information will be shared only on a need-to-know basis;
    - Explaining that the employee will remain anonymous on any communications of lessons learned; and
    - Remaining cordial and professional even if the interviewee is not cooperative.

6.2 Developing the Narrative:

- Collect the facts and ask the interviewee to relate the events of the incident in his or her own words. Allow the person to complete each statement and do not fill silences with leading questions.
- Construct a timeline. Pay close attention to the sequence of events in order to establish a timeline, and identify critical elements for future clarification or expansion.
- Take photos of the area and equipment involved. Avoid taking photos of people.
- Clarify critical elements:
    - Based on the interviewee’s statements, prompt him/her to elaborate on critical information.
    - Ask open-ended questions to help clarify important information.
    - Avoid using emotive or judgmental language.
    - Do not prompt interviewee to speculate. Record only what the interviewee considers factual.
- Ask control questions. Ask questions for which you already know the answer, to give you a basis for evaluating the current reliability of the interviewee’s statements.
- Confirm accuracy. Periodically summarize events for the interviewee to confirm the information has been accurately recorded.

6.3 Collecting Additional Information:

- Once the narrative has been developed, ask the interviewee how the incident could have been prevented.
- Thank the interviewee for cooperating with the investigation.

- Exchange contact information so that both parties can follow up; the interviewer may have additional questions, and the interviewee may remember additional details after the interview has been concluded.

6.4 Causal Factor Analysis:

- After the incident investigation has been completed, the information gathered should allow for the development of the causal factors. Below is a summary of the causal factor analysis process:
  - Identifying the causal factors will help determine the appropriate corrective actions.
  - In many cases more than one causal factor is identified.
  - Focus on the causal factors that are most applicable to the incident.

6.5 Identifying the Causal Factors:

It is important to identify the causal factor(s) related to the incident. Using this tool will allow for you to better determine the cause of the incident, and help to focus on the appropriate corrective actions. The National Safety Director will help in determining applicable causal factors. Please see below the casual factor categories and potential selections.

Communication	**Behavior**	**Equipment/Tools**
• Management Risk Acceptance; • Poor Pre-Job Briefing; • Poor Work Planning; • Responsibilities Not Identified; and • Unclear Work Assignments.	• Disregard for Rules; • Inexperienced; • Mental State/Medication; • Physical Capability; • Poor Judgement; • Predisposition to Injury; and • Risk Taking.	• Defective or damaged; • Excessive Wear; • Improper Use; • Inadequate Maintenance; • New or Modified Equipment; • Not Readily Available; • Poor Design; and • Not Used.
Human Factors	**Management Systems**	**Personal Protective Equipment**
• Controls; • Displays; • Inadequate Material Handling Devices; • Labels; • Lifting more than 50 lbs.; • Position of People/Equipment; • Pushing/Pulling in excessive force; or • Repetitive Motion.	• Lack of Hazard Recognition and risk mitigation; • Poor Engineering/Design; or • Unclear Accountability.	• Improper Use; • Inadequate; • In Poor Condition; • Not Readily Available; and • Not Used.

Training	**Procedures**	**Working Environment**
• Incomplete Training; • Ineffective Training; • None Developed; • Lack of Competence; • Not Followed; and	• Ambiguous Instruction; • Error in Procedure; • Improper Procedure Used; • Infrequent Procedure; • No Pre- Start Check Off; • No Procedure; • Pre-Start Check Off Not Used; • Procedure Inconvenient; • Procedure Not Required, Should Be; and • Process Change	• Arrangement/Placement; • Chemicals/Dust; • Climate/Weather; • Congestion; • Cramped Quarters; • Fall Hazards; • Housekeeping; • Illumination; • Noise; • Obstructions; • Slip/Trip Hazards; and • Ventilation

7 CORRECTIVE ACTIONS, VERIFICATION AND VALIDATION, AND LESSONS LEARNED REPORT

The next step in the process is to develop and implement the corrective actions, verify and validate that the corrective actions were successful, and disseminate the lessons learned report to TRC employees.

7.1 Development of Corrective Actions:

- Hazard mitigation methods generally fall into four categories:
  - Engineering or mechanical controls or job redesign—This is the preferred method since it eliminates or reduces the hazard and is a permanent solution. We will use this solution when possible.
  - Administrative Control—May include modifying a standard work practice and/or procedure or operational/systemic practice. An example is to limit the amount of time an employee is exposed to a repetitive operation, or exposed to a noisy environment.
  - Training—Once a safe job procedure has been established, employees can be trained in the proper (safe) method to do the job. While training is always desirable (and is required by law), a challenge with this solution is that it requires constant supervision to ensure employees continue to do the job in the manner in which they were trained.
  - Personal Protective Equipment (PPE)—It is necessary to use hearing protection for noisy areas, proper gloves for material handling or exposure to chemicals or other material, steel-toe boots and hard hats for protection against physical injury, and respirators to guard against exposure to air contaminants. This solution requires an evaluation of the proper PPE, additional training if necessary, and supervision and periodic inspection to ensure the equipment is used properly.

The corrective actions will be developed by a team of individuals consisting of the employee(s) that were onsite, the Project Manager/Supervisor, the National Safety Director and the Office Safety Coordinator. Other people may be involved depending on the severity of the incident or the complexity in developing corrective actions. Investigation findings will be tracked on the TRC Incident Investigation form.

7.2 Verification and Validation of Corrective Actions:

The corrective actions that are formulated and implemented must be verified and validated to ensure that employees are using the new safety controls and that the controls established are serving the purpose in eliminating the hazardous condition(s). Sometimes corrective actions may introduce additional safety hazards that may not be apparent until they are applied in the field. In addition, the verification and validation process allows for opportunities to photograph the corrective action while in process, which can be used in the Lessons Learned Report to follow. To identify that the safety controls are implemented and working, an observation must be planned.

7.3 Dissemination of Lessons Learned Report:

- The communication of the Lessons Learned Report is the final step. The report is designed to provide each employee with a quick summary of the incident, causal factor(s), and short- and/or long-term corrective actions. A sample of the Lessons Learned Report is provided Appendix B.
  - Sources of these lessons include incidents, First Aid cases, near misses, safe catches and observation findings from projects and offices throughout TRC. The program is designed to help TRC employees understand how to respond to safety incidents, and prevent recurrences by raising awareness of the risks associated with key incidents, and communicating practical solutions to improve behavior and mitigate safety hazards.
- Where appropriate (typically only for very high-risk occasions or where similar reportable incidents are repeated) the National Safety Director may send a formal notice to staff and Subcontractors requiring a change of work practice(s) and request an acknowledgement signature from employees and Subcontractors associated with the Project Team.
- It is the expectation that this program will provide employees and Subcontractors with a clear understanding of how to respond to safety incidents, conduct investigations, determine causal factors and corrective actions, and disseminate lessons learned to employees.

8 COMPLETE TRC INCIDENT REPORT FORM

8.1 The employee(s) and their direct supervisor shall use the information gathered through the investigation process to complete CP019 TRC Incident Investigation Report.

8.2 The report should be submitted to TRC's National Safety Director as soon as it's completed.

9 REFERENCES/RELATED DOCUMENTS

29CFR1904.39
Appendix A – Incident Response Flowchart
Appendix B – Example Lessons Learned Report
Appendix C – Incident Notification Report
Appendix D – Auto Incident Report
Appendix E – Safe Catch Report

APPENDIX A
INCIDENT RESPONSE FLOWCHART

INCIDENT RESPONSE AND REPORTING FLOWCHART

INCIDENT RESPONSE

INCIDENT OCCURS

***Incident Types*:**

- Injury
- Illness
- Property Damage
- Near Miss/Near Loss
- Safe Catch
- Environmental Incident

Respond according to site-specific Health and Safety Plan (HASP) and TRC Emergency Action Plan

Need for Immediate Outside Emergency Services?

YES

MAYBE

CALL 911

NO

TRC Employee

- Determine immediate response actions
- Administer First Aid/CPR to level of competency
- Control/contain incident, if safe to do so
- Call Project Manager/Supervisor to report incident
- Call **WORKCARE** at **(888) 449-7787**
- Gather incident information (take notes, photos, witness info, drawings, etc.)

Project Manager/Supervisor

- Notify a member of the Corporate Health and Safety Team and your manager (in that order)
- Assist with developing immediate response actions, evaluate need for additional TRC support to scene for assistance, and deploy as needed
- Gather incident information from on-site employee
- Visit site to assess scene, as required

TRC Safety Director

Mike Glenn (949) 727-7347 or (949) 697-7418 - cell

APPENDIX B
EXAMPLE LESSONS LEARNED REPORT

TRC Results you can rely on

August 2016

LESSONS LEARNED REPORT

HEAT-RELATED ILLNESS!

HIGH TEMP + HIGH HUMIDITY = HEAT STRESS

INCIDENT SUMMARY

A TRC employee, began to feel the effects of heat stress as a result of the environmental conditions. As the summer temperature increased to 88 degrees Fahrenheit, the employee became saturated with sweat, nauseous, hands began to tremble, and fell short of breath. The employee notified the crew supervisor on-site of his condition. The employee was immediately given water to rehydrate and rest in an air-conditioned vehicle. WorkCare was called and based on the employee's symptoms, medical attention was recommended. The field supervisor located the nearest medical facility listed on the project-specific Health and Safety Plan and transported the employee to be evaluated. The employee was diagnosed with heat exhaustion and intravenous fluids were administered. Thankfully, the employee was cleared for discharge shortly thereafter and was able to return to regular work duty the following day.

CONTRIBUTING CAUSES/FACTORS

- **Extreme Heat**
  - Ambient air temperature exceeds **85 degrees** with relative humidity greater than **50 percent**. Temperature on this particular day was **88 degrees** with a relative humidity of **68 percent**.
- **Modified Work/Rest Schedule**
  - Additional rest breaks should have been introduced based on the extreme temperatures associated with the work day.
- **Acclimated to the Task**
  - The employee had not worked regularly in the field in recent months so was not acclimated to the environmental conditions.
- **Maintain Body Fluids**
  - A total of 1 to 1.5 gallons of water per individual per day are recommended for fluid replacement under heat stress conditions. The employee was not drinking enough fluids for the environmental conditions.

CORRECTIVE ACTIONS

- **Stopped Work** – Administered fluids and removed the employee from the environmental conditions.
- **WorkCare** – Notified the incident intervention service of the situation.
- **Medical Attention** – Evaluation and corrective measures.
- **Modified Work Schedule** – Work schedule has been adjusted to 30-minutes on/30-minutes off during extreme heat days.
- **Fluid Intake** – Project staff will consume 32 ounces of water per working hour to ensure proper hydration. A water supply will be readily available on-site, in coolers with ice, no more than 100 meters from staff at all times.
- **WBGT Thermometer** – A Wet-Bulb Globe Temperature (WBGT) thermometer will stay on-site at all times to accurately measure the ambient air temperature and relative humidity.
- **Staff Messaging** – Safety Reminder circulated to staff. TRC's Heat Stress Prevention Program reviewed with project team.

LESSONS LEARNED

- **Monitor Physical Conditions** – Field staff should have had increased awareness of their physical condition and their fellow co-worker's condition for signs or symptoms of heat illnesses. **The Buddy System**—staff should be asking each other: How are you feeling? Nauseous? Shaky? Need a break? How much fluid have you had this hour?
- **Environmental Conditions Responsiveness** – Field staff should have avoided heavy exertion, extreme heat, sun exposure, and high humidity when possible. Work schedule should have been adjusted to accommodate more frequent rest periods and an altered work start time to conduct field tasks during the cooler portions of the day.
- **Safety Communication** – Incident review interviews determined that heat-stress was a topic of discussion at the Daily Pre-Task Safety Briefing. Continued heat discussions will take part of all Safety Briefings to highlight the importance of environmental conditions awareness and management.

Contact: If you have any questions about this report or would like additional information please contact Curt Biondich, PPL Safety Coordinator at cbiondich@trcsolutions.com or Mike Glenn, TRC Safety Director at mglenn@trcsolutions.com.

APPENDIX C
INCIDENT NOTIFICATION REPORT

INCIDENT NOTIFICATION REPORT

(To be completed immediately after an Injury, Illness, Incident or Significant Near Miss by Employee's Supervisor and Employee involved)

Incident Category

☐ Injury/Illness ☐ Near Miss/Loss ☐ Property Damage ☐ Other

1 Incident Location: ______________________________

2 Project #: ______________________________

3 Client: ______________________________

4 Date Incident Occurred: ______________________ Time: ________

5 Date Incident Reported: ______________________ Time: ________

TRC Employee Information

6 Name: ______________________ Phone: ________

7 Office: ______________________ Address: ________

8 Supervisor Name: ______________________ Phone: ________

9 Title or Occupation: ______________________________

10 Sector/Practice: ______________________________

Incident Description

11 Task Performed/Description of Incident:

____

12 Conditions at the Time of Incident (weather, lighting, etc.):

____

13 Description of Property Damage:

Employee Injury or Illness Description

14 Describe the Injury or Illness:

____

15 First Aid/Medical Treatment Administered:

____

16 Was WorkCare Contacted? ☐ Yes ☐ No

17 Name of Doctor's Office, Clinic or Hospital: ______________________

18 Address: ______________________ Phone: ________

INCIDENT NOTIFICATION REPORT

(To be completed immediately after an Injury, Illness, Incident or Significant Near Miss by Employee's Supervisor and Employee involved)

Subcontractor Involvement

19 Was a subcontractor involved? ☐ Yes ☐ No

20 Name of Company: ______

21 Address: ______

22 Contact Name: ______ Phone: ______

23 Description of the Incident:

Witness Information

24 Were there witnesses to the incident? ☐ Yes ☐ No

25 Name(s) Address(es) Number(s)

______

______

Immediate Corrective Actions

26 Describe the Immediate Corrective Actions Taken:

Client Notification

27 Is there a client incident notification requirement? ☐ Yes ☐ No

28 Contact Name ______

29 Date of Notification: ______ Time: ______

30 Notification Method:

Supervisor: ______ Signature: ______ Date: ______

Employee: Signature: Date:

APPENDIX D
AUTO INCIDENT NOTIFICATION REPORT

AUTO INCIDENT REPORT

EMPLOYEE INFORMATION (V-1):

Name: ______________________ Phone: ( ) ______________________

Sector/Practice: ______________________ Office Location: ______________________

Supervisor's Name: ______________________ Supervisor's Phone: ( ) ______________________

Project #: ______________________ Client's Name: ______________________

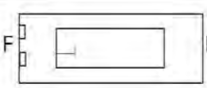
Driver's License #: ______________________ State: ______________________

VEHICLE INFORMATION (V-1):

Year/Make/Model of Vehicle: ______________________

License Plate #: ______________________ Vehicle ID # (VIN): ______________________

Circle Point of Contact:



Was Vehicle Drivable? ☐ Yes ☐ No

Personal: ☐ Yes Rental: ☐ Yes Fleet: ☐ Yes

Rental Company

INCIDENT INFORMATION:

Date of Incident: __________ Time of Incident: ______ A.M. ______ P.M. Photos Taken: ☐ Yes ☐ No

Location of Incident: ______________________ City/State: ______________________

Were The Authorities Contacted? Police: ☐ Yes ☐ No Ambulance: ☐ Yes ☐ No Fire: ☐ Yes ☐ No

Name of Police Dept: ______________ Case #: ______________ Officer Name: ______________

Were Citations Issued? ☐ Yes ☐ No If Yes, To Whom? ______________________

Citation Number: ______________________

Were There Any Witnesses? ☐ Yes ☐ No If Yes, Please Provide Name, Address and Phone Below:

Witness Name: ______________________ Witness Phone: ( ) ______________________

Witness Address: ____

Traffic Conditions (i.e., heavy, light): ______________ Weather Conditions (i.e., dry, wet, ice, fog): ______________

WorkCare Contacted? ☐ Yes ☐ No

TRC Driver Injured? ☐ Yes ☐ No Medical Treatment Received? ☐ Yes ☐ No

Front Seat Passenger Injured? ☐ Yes ☐ No Medical Treatment Received? ☐ Yes ☐ No

Rear Driver Side Passenger Injured? ☐ Yes ☐ No Medical Treatment Received? ☐ Yes ☐ No

Rear Passenger Side Passenger Injured? ☐ Yes ☐ No Medical Treatment Received? ☐ Yes ☐ No

Describe Injuries:

____

Describe Damage to Property Other Than Motor Vehicles (i.e., guardrails, mailboxes, etc.):

____

AUTO INCIDENT REPORT

OTHER DRIVER & VEHICLE INFORMATION (V-2):

Driver's Name: ______________________ Driver's Phone: ( ) ______________

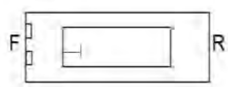
Driver's Address: ____

Owner's Name (If different than driver): ______________ Owner's Phone: ( ) ______________

Owner's Address: ____

Year/Make/Model of Vehicle: ______________ License Plate #: __________ State: ______

Circle Point of Contact:



Was Vehicle Drivable? ☐ Yes ☐ No

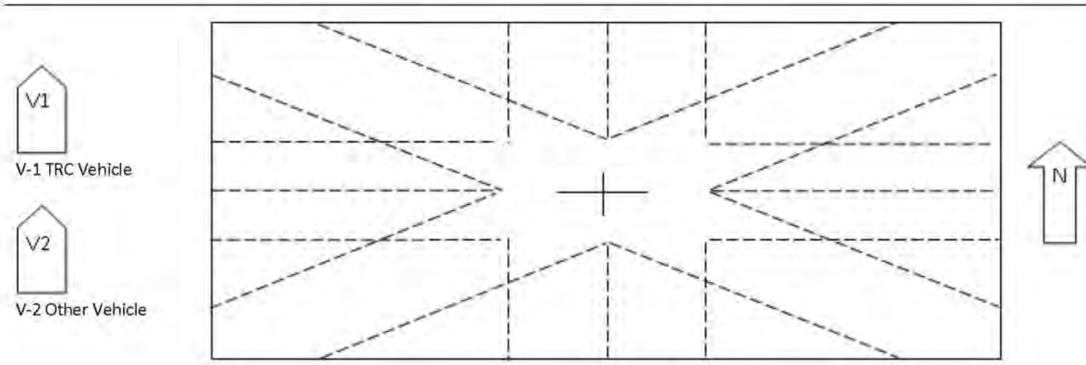
Insurance Company Name: ______________________ Policy Number: ______________

Insurance Company Phone: ( ) ______________ Number of Passengers in Vehicle: ______

List Persons Injured: ____

Were Any Other Vehicles Involved in Incident? ☐ Yes ☐ No If yes, provide details below:

PLEASE DESCRIBE THE INCIDENT AND COMPLETE THE DIAGRAM BELOW. Be sure to indicate as many details as possible (i.e., How many lanes in each direction; Were there any turn lanes; What kind of traffic controls were there – light, stop sign, yield sign, Positions of vehicles on impact).



Completed By: ______________________ Signature: ______________

APPENDIX E
SAFE CATCH REPORT

"Safe Catch" Report

A "Safe Catch" is a potential hazard or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries. It is everyone's responsibility to report and/or correct these potential incidents immediately. Please complete this form as a means to report these "Good Catch" situations and submit to your local OSC Representative and Mike Glenn, National Safety Director.

Complete ALL field entries:

Employee Name:		Date:	
Location:		Office:	
Project Number:		Practice:	

Conditions

Please check all appropriate conditions:

☐ Unsafe Act ☐ Unsafe Condition ☐ Unsafe Equipment ☐ Unsafe Use of Equipment

Description of Incident or Potential Hazard:

Task Performed at Time of Incident:

Causes (Primary and Contributing):

Corrective Action(s) Taken (remove the hazard, replace, repair, or retrain):

Employee Signature:		Date Completed:	

Our Mission: To reduce the frequency of incidents by applying local lessons learned globally.

If you have any questions about this report or would like additional information, please reference Compliance Program CP019—TRC Incident Response and Lessons Learned Program, located on TRCNET or contact Mike Glenn, National Safety Director at mglenn@trcsolutions.com.

1. PURPOSE

The purpose of this plan is to document spill prevention and response requirements. If required, a properly trained TRC employee will develop a spill prevention and response plan based on the requirements and template provided or similar (Appendix A).

2. SCOPE

This procedure applies to all TRC operations. When work is performed on a non-owned or operated site, the operator's program shall take precedence, however, this document covers TRC employees and contractors and shall be used on owned premises, or when an operator's program doesn't exist or is less stringent.

3. RESPONSIBILITIES

3.1 Supervisors:

- Supervisors should ensure that employees are familiar with these procedures and receive necessary training.

3.2 Employees:

- Responsible for following this program and for reporting all spills to their supervisor.

4. PROCEDURE

4.1 General Requirements:

Each work site spill prevention and response plan shall contain the following requirements.

- Chemical substances should be stored in proper containers to minimize the potential for a spill. Whenever possible, chemicals should be kept in closed containers and stored so they are not exposed to storm water.
- The program must identify chemicals used that may be potentially spilled or released. This will include both liquid chemicals used at our facilities or brought on to owner client sites.

- Spill kits must be adequate for any anticipated spills. A proper spill kit must contain the appropriate supplies for materials that may be spilled. Supplies must be easily accessible when required, and considerations must be made for both the type and quantity of materials. The contents of spill response kits shall be periodically assessed to ensure the availability of adequate spill response supplies and adjust inventory as necessary.
- TRC employees and contractors shall ensure the availability of adequate spill response supplies by periodic inspection to assess their availability and adjust the inventory as necessary.
- Areas where chemicals may be used or stored must be maintained using good housekeeping best management practices. This includes, but is not limited to clean and organized storage, labeling and secondary containment where necessary.
- Proper communication measures for employees to initiate in the event of a spill will be created on a site by site basis. Communication procedures will be based on type and quantity of materials spilled.
- Environmental spills shall be reported to environmental authorities when required. Reporting procedures will be based on type and quantity of materials spilled.

5. TRAINING REQUIREMENTS

- Employees must be instructed on spill prevention and the proper response procedures for spilled materials. The training should include materials available for use, proper waste disposal and communication procedures.

6. REFERENCES/RELATED DOCUMENTATION

CP002 – Risk Analysis/Site-Specific Health and Safety Program

7. APPENDICES

A – Spill Prevention and Response Plan Template

Appendix A

<u>Copies of this plan are located at the facility and are available to all employees.</u>

Location(s) of plan(s): ____

<u>Facility Information</u>

Facility Name: ____________________________________

Mailing Address: ____
____

Physical address if different: ____
____
____

Owner Name: ____

Owner Address: ____
____

Primary Contact Name: ____
Work Phone Number: ____
Home Phone Number: ____
Mobile Phone Number: ____

Secondary Contact Name: ____
Work Phone Number: ____
Home Phone Number: ____
Mobile Phone Number: ____

Date of Initial Operation: ____

<u>Site Assessment</u>

Location - Describe where facility is located.

____
____
____

Facility Description

Facilities and Equipment (*examples are shown but complete per site description*):

____ Garage for vehicle processing
____ Parts storage
____ Manufacturing Building
____ Spill kit/emergency equipment
____ Refrigerant (Freon) extractor
____ Parts washer

Please list: ________________________________
____
____
____
____

Services:

____ Dismantler/Recycler
____ Equipment Repair
____ Moving Equipment
____ Painting/Sandblasting
____ Manufacturing

Please list: ________________________________
____
____
____

Fixed Storage - List capacity and contents of each storage container. For example, "One 6,000 gallon above ground tank containing diesel fuel." Be sure to include diesel, gasoline, waste oil, heating oil, kerosene, paint thinner and other solvents. Also describe the construction of the containers, secondary containment for each, liquid level indicators, alarms and method of corrosion protection for each container.____
____
____
____
____
____
____

Non-Fixed Storage - List capacity and contents of each storage container. For example, "One 55 gallon drum for recycled oil." Be sure to indicate what each container is used for, its condition and construction and how secondary containment is provided. ____
____
____
____

Total quantity of stored materials: - The combined quantity of the materials listed above: _________ gallons

Oil spill history

Place an X on the appropriate line and proceed accordingly.

___ There has never been a significant spill at the above named facility.

___ There have been one or more significant spills at the above named facility. Details of such spill(s) are described below. For each spill that occurred, supply the following information:Type and amount of oil spilled

- Location, date and time of spill(s)
- Watercourse affected
- Description of physical damage
- Cost of damage
- Cost of clean-up
- Cause of spill
- Action taken to prevent recurrence

____

____

____

____

Potential Spill Volumes and Rates

Fill in all applicable blanks.

Potential Event	Volume Released	Spill Rate
Complete failure of a full tank*	___ gallons	instantaneous
Partial failure of a full tank*	1 to ___ gallons	gradual to instantaneous
Tank overflow**	1 to ___ gallons	up to ___ gallons per minute
Leaking during unloading***	up to ___ gallons	up to ___ gallons per minute
Pipe failure****	up to ___ gallons	up to ___ gallons per minute
Leaking pipe or valve****	several ounces to gallons	up to ___ gallons per minute
Fueling operations****	several ounces to gallons	up to ___ gallons per minute
Oil and grease	several ounces to quarts	spotting

* Volume of largest tank

** Calculate using the rate at which fuel is dispensed from the delivery truck into your tank(s).

*** Calculate using the rate at which petroleum would be withdrawn from the tank if it should have to be emptied (*e.g.,* if it was being taken out of service).

**** Calculate based on the specifications of your equipment.

Spill Prevention and Control

Spill Prevention - Provide specific descriptions of containment facilities and practices. Include description of items such as double-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. Also, describe how and when employees are trained in proper handling procedures and spill prevention and response procedures.

Spill discharge and flow - For each potential spill source; describe where petroleum would flow in the event of a spill. For example, "The 6,000 gallon diesel tank has a pre-manufactured secondary containment system capable of holding 110 percent of the total volume of the tank" and, "A spill from engine repair would be contained inside the shop building and quickly cleaned up with oil absorbents." Incorporate site map by reference (see instructions under *Appendices*).

Spill response - Identify what equipment would be deployed by whom and in what situation. Also, include phone numbers for response agencies, *e.g.,* U.S. Coast Guard, fire department, spill response contractors, etc. A copy of your spill response plan may be attached as an appendix to this plan in lieu of completing this section.

____
____
____
____
____
____
____
____
____
____

Security - Provide a description of how all containers are protected when the facility is not in operation or unattended. Include a description of fencing, access control, gates, locks, etc. that prevent access by unauthorized individuals.

____
____
____
____

Facility Inspections

Routine Inspections - Name facilities and the frequency with which they are inspected. For example, "The fuel pumps are inspected daily. The materials storage area is inspected monthly." Describe all facility containers, piping, etc. that is to be inspected. Name the person who has responsibility to implement preventative maintenance programs, oversee on-site inspections, coordinate employee training, maintain records, update the plan as necessary, and ensure that reports are submitted to the proper authorities.

Annual Inspections - Include a description of annual comprehensive inspections. For example, "A site inspection is also conducted annually by appropriate responsible personnel to verify that the description of potential pollutant sources are accurate, that the map reflects current site conditions, and that the controls to reduce the pollutants identified in this plan are being implemented and are adequate. This annual inspection will be conducted above and beyond the routine inspections done focusing on designated equipment and areas where potential sources are located."

Record Keeping

Describe record keeping procedures. For example, "Record keeping procedures consist of maintaining all records a minimum of three years. The following items will be kept on file: current plan, internal site reviews, training records, and documentation of any spills or maintenance conducted in regards to these sites." *Maintenance Inspection, Employee Training,* and *Record Keeping* logs are included in this template for your use.

Maintenance Inspections

Maintenance Coordinator Name:

Maintenance Coordinator responsibilities include implementation of preventative maintenance programs and oversight of on-site inspections.

Use this table to record inspections:

Facility Inspected	Date of Inspection	Name of Inspector	Result Pass/Fail	Comments

Employee Training

Employee Training Coordinator Name: ____________________

Use this table to record spill prevention and response training.

Name of Employee	Date of Training	Type of Training/Topics Addressed

Record Keeping of Incidental Spills

Record Keeper Name:

Record Keeper responsibilities include maintaining records of incidents, updating the plan as necessary and ensuring reports are submitted to the proper authorities when necessary.

Incident No.	Type of Incident	Date of Occurrence	How it was Cleaned Up

Appendices

Site map - Attach a site map as Appendix A to this plan. You may attach an existing site map or create your own. If you use an existing map, be sure that the items listed below are included. If you need to create a site map, use a large enough piece of paper so all site plan elements may be seen and try to keep the map to a scale (e.g. 1" = 20' The following instructions should guide you step-by-step. Please use a straight edge (ruler) while creating the sketch.

- The sketch should be oriented as if you were in a plane looking down on your property (an aerial view), with North at the top (draw an arrow indicating north).Draw and label all roadways surrounding the work site.
- Draw and label all facilities within the work site as close proportionately as possible.
- Draw an arrow(s) pointing in the direction of downhill flow of water when it rains.
- Draw the location and general layout of all vehicles associated with the work site.
- Label any rivers or waterways surrounding the work site.
- Draw and label all methods of entry to the work site.
- Draw and label the location of all fuel containment facilities.
- Draw and label the location of all in-place spill prevention, control and countermeasure devices.

Other attachments - List any additional information to be attached as Appendix B, C, D, etc. Label and staple the attachments to the end of this plan.

Appendix A: Site Map
Appendix B: Emergency Response Posting Locations
Appendix C: ____________________________
Appendix D: ____________________________

Management Approval

I certify that I have personally examined and am familiar with the information submitted in this document and that, based on my inquiry of those individuals responsible for obtaining this information, the information submitted is true, accurate and complete.

_______________________________ ______________________

Signature *Title*

_______________________________ ______________________

Printed name *Date*

Appendix B
Generic Health and Safety Plan Review Log

GENERIC HASP REVIEW LOG

Date	Reason for Review/Revision	Reviewed By	Summary of Review/Revision

Appendix C
Site-Specific Health and Safety Plan Template

SITE-SPECIFIC HEALTH AND SAFETY PLAN

[SITE NAME]
[CITY/TOWN NAME], NEW YORK [ZIP CODE]
NYSDEC Site No. [######]
Work Assignment No. D009812-[##]

Prepared for:
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, NY 12233

Prepared by:
TRC Engineers, Inc.
1430 Broadway
New York, New York 10018

TRC Project No.: [######].0000.0000

[Month and Year]

Table of Contents

List of Tables

List of Appendices

1. Site/Project Contact Information

Table 1 – Site/Project Contact Information			
Site Information			
Site Name	**Site No.**	**Address**	
[Specify]	[Specify]	[Specify]	
Client Contact			
Name	**Organization**	**Title**	**Primary Phone No.**
[Specify]	[Specify]	[Specify]	[Specify]
[Specify]	[Specify]	[Specify]	[Specify]
TRC Personnel and Project Role			
Name	**Role**	**Email**	**Primary Phone No.**
Michael Glenn	Health and Safety Officer (HSO)	mglenn@trccompanies.com	(949) 697-7418 (cell)
David Sullivan	Assistant HSO	dsullivan@trccompanies.com	(978) 758-2809 (cell)
James Magda	Contract Manager	jmagda@trccompanies.com	(315) 415-4315 (cell)
[Specify]	Project Manager	[Specify]	[Specify]
[Specify]	Office Safety Coordinator (OSC)	[Specify]	[Specify]
[Specify]	On-Site HSO	[Specify]	[Specify]
[Specify]	Field Staff	[Specify]	[Specify]
[Specify]	Field Staff	[Specify]	[Specify]
Subcontractor Information			
Company Name	**Service**	**Primary Contact**	**Primary Phone No.**
[Specify]	[Specify]	[Specify]	[Specify]
[Specify]	[Specify]	[Specify]	[Specify]
Emergency Assistance			
Service	**Name**	**Emergency No.**	**Primary Phone No**
Ambulance	[Specify]	[Specify]	[Specify]
Early Incident Intervention	WorkCare	1-888-449-7787	Not applicable
Fire	[Specify]	[Specify]	[Specify]
Hospital	[Specify]	[Specify]	[Specify]
Police	[Specify]	[Specify]	[Specify]
Poison Control Center	[Specify]	[Specify]	[Specify]
Spill	CHEMTREC	Not applicable	1-800-424-9300 (TRC No. CCN 671126)
Spill (Federal)	National Response Center	1-800-424-8802	Not applicable
Spill (State)	New York State Spill Hotline	1-800-457-7362	Not applicable

2. Medical Facility Identification and Directions

Nearest Hospital: [Specify]

Hospital Address: [Specify]

Hospital Telephone Number: [Specify]

Directions to Hospital (see attached Map):

[Insert turn by turn directions to the hospital from the site.]

Map to Hospital:

[Insert a map to the hospital from the site.]

3. Utility Clearance

Dig Safely New York and non-member utilities will be notified at least 72 hours prior to commencing any ground intrusive work. Prior to the start of work, confirmation receipts will be reviewed, and utility mark-outs will be verified.

[Add/delete/modify the following text as needed based on site conditions/scope of work - A private utility survey will be required to survey the proposed soil boring, monitoring well and test pit locations using at a minimum Ground Penetrating Radar (GPR) and Electro-Magnetic/Radio Frequency (EM/RF) Pipe, Cable and Box locator. The survey shall encompass an area extending in all directions at least 10 feet beyond each of the locations.]

[Add/delete/modify the following text as needed based on site conditions/scope of work - Any structure detected in the subsurface within 10 feet of the proposed soil boring, monitoring well and test pit locations will be identified on the ground surface with spray paint. Results of the utility survey will be reviewed in the field between TRC and the utility surveyor the same day the service is provided. Results will also be summarized in a brief utility survey report which shall be prepared by the utility surveyor and submitted to TRC. Additionally, all proposed locations will be hand-cleared prior to commencement of intrusive activities to confirm absence of underground utilities.]

Prior to the operation of any heavy equipment, the site shall be inspected for potential overhead hazards (e.g., wires, tree branches, etc.). A minimum clearance of 10 feet must be maintained between equipment and overhead utility lines. If contact is possible (i.e., equipment, drill rig, excavator, etc.) one or more of the following will be done: 1) Power sources will be disconnected by the utility; 2) Power sources will be shielded by the utility; 3) Object will get no closer than 10 feet to prevent arcing, unless site specific conditions or weather conditions warrant greater separation per best professional judgment, or as directed by utility representatives; and, 3) Evaluate the need for shielding and coordinate with local utility representatives.

4. Scope of Work Summary

[Summarize the specific scope of work to be completed from the approved Work Assignment Package in paragraph and/or bulleted text. Provide enough detail so the reader is knowledgeable with the Scope of Work, project objectives, and field means/methods.]

5. Hazard Assessment

This Health and Safety Plan (HASP) assumes that an ongoing hazard assessment process with the HSO (or his/her designee), Project Manager, OSC and field staff (including the On-Site HSO) will take place regularly (via meetings/teleconferences), supplemented by as needed communication on project safety needs, to ensure the project work is conducted at a high level of technical excellence both safely and efficiently. Where the on-going hazard assessment indicates the presence of hazards, tasks, or other activities that are not adequately covered by the HASP and supporting documentation and/or staff training levels, supplemental planning will be conducted and documented in a revised or higher-level HASP document and appropriately trained personnel assigned.

5.1 Chemical Hazards

The following contaminants are known and/or suspected to be present at the site:

[Insert bulleted list of contaminants.]

TRC also anticipates the presence of the following chemicals in laboratory bottles used as sample preservatives: [specify]. In addition, TRC anticipates the use of methyl alcohol (methanol) during decontamination procedures. Safety Data Sheets (SDS) for preservatives and decontamination products are provided in **Appendix A**. Sample bottles containing hazardous preservatives will be handled with care. Sample bottles will be checked for leaks and lids tightened. Cut resistant and chemical resistant gloves and safety glasses will be worn at all times when handling sample bottles (see Section 5.2 for information concerning edges and material handling).

Isobutylene may be used for brief periods each work day to calibrate a photoionization detector (PID). One hundred parts per million (ppm) isobutylene will be primarily contained in a Tedlar® bag. Any gas that is released to the air will quickly disperse and will not pose a threat to on-site workers. No further monitoring is required for isobutylene

5.2 Physical Hazards

Physical hazards that may be encountered at the site are outlined below. If hazards are identified by the ongoing hazard assessment process, which are not address by this HASP, work shall be stopped and the HSO (or his/her designee), Project Manager, OSC or On-Site OSC, as appropriate, shall be contacted to determine if additional safety procedures and programs should be employed at the site.

[Add physical hazards to or delete physical hazards from the list below, as appropriate]

Dust – When conducting any ground disturbing activities, be cognizant that the dust has potential to contain hazardous chemicals and should not be inhaled. Whenever possible dust reduction by wetting shall be used. If dust is billowing, wetting the area, letting the dust settle, working from an upwind direction, and/or respirator with P100 cartridges (with proper fit test, training and medical monitoring) is recommended to reduce exposure.

Edges/Material Handling – Cut resistant gloves are required to be worn at all times while performing tasks that have the potential for hand injuries. A glove selection guideline is presented in **Appendix B**.

Excavations – Stay clear of excavation walls. TRC personnel will not enter an excavation, in accordance with 1926 Sub Part P. Subcontractor must provide a competent person on site, if one is required by the planned activities. Side cuts should conform to 1926 Subpart P requirements, or shoring should be used. All open excavations should be secured using traffic cones, barrier tape, or barricade signs stating "Do Not Enter Excavations", especially if left open overnight. See **Appendix C** for an Excavation Hazard Recognition Guide for Trenching and Shoring and Site Assessment Questions to facilitate your understanding of potential hazards and other guidance.

Ground Fault Circuit Interrupters (GFCI) and Electrical Cords – GFCIs will be used on all 120 volt, single phase, 15 and 20-ampere receptacle outlets when electrical equipment is used on-site. Electrical cords will be inspected for cracks, tears, or general wear to the outer protective casing. If the wiring of the cord is exposed, the cord will be repaired, if possible, or discarded. All extension cords will contain a grounding prong. If the grounding prong is missing, or if the cord was designed to contain only two prongs, the cord will not be allowed for use. These cords are dangerous and cannot be grounded through the use of a GFCI.

Hand Tools – Use only the appropriate tool for the task at hand. Use the tool(s) as designed, described, and intended by the manufacturer. Hand tools will meet the manufacturer's safety standards. Hand tools will not be altered in any way. Makeshift tools will not be used. At a minimum, hand and eye protection will be used when working with hand tools (see glove selection guide provided herein). Wrenches, including adjustable, pipe, end and socket wrenches, will not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges and chisels, will be kept free of mushroom heads. Wooden handles will be free of splinters or cracks and secured tightly to the tool. At all times use appropriate hand protection when utilizing hand tools.

Heavy Equipment/Drill Rigs – Use caution around drill rigs, construction equipment, and open excavations. Ensure the equipment operator is aware of the location of on-site personnel at all times to avoid potential injuries (e.g., maintain eye contact with the equipment operator). A spotter should be used to direct the movement of heavy equipment. A swing zone should be established with cones behind any excavators to prevent injury during movement of equipment. Exercise caution and wear protective equipment as noted herein around the equipment to guard against crushing and pinching hazards. On-site personnel will maintain a distance (approximately 10 feet) from mechanical hazards associated with heavy equipment. All field team members working near or with equipment with emergency shut-off switches should be aware of the locations and situations when these switches should be used.

Hostile Individual(s) – Most personnel who are encountered during work will not be hostile, however if a hostile individual is encountered you should not confront them. You should back away and go to your vehicle or other safe location where you can isolate yourself from the hostile person(s). Once safe, if you are continuing to be harassed you should contact the local police for assistance. Contact the Project Manager or OSC once the situation is safe and under control.

Hunters/Firing Range, etc. – Be aware of surrounding activities that may involve hunting, firearms, etc. that may not be in your immediate area, but could be create an unsafe work environment.

Lighting – There are areas/time within the work area(s) at the site which will potentially have little to no lighting. Lighting shall be utilized to make the work area and nearby hazards are illuminated. If gasoline powered equipment must be used to power portable lights, the generator shall be placed outside in a well ventilated area.

Manual Lifting – Improper lifting can lead to a variety of injuries including back strains, muscle pulls and joint damage. It is important for all personnel to understand proper lifting techniques and to utilize safe lifting procedures when handling materials. Generally, no one person should lift more than 50 pounds without assistance. Mechanical means should be used whenever possible.

Noise – Hearing protection must be worn when noise levels exceed 85 dBA in the work area. If you need to raise your voice to be heard at the work site, then hearing protection should be worn. Hearing protection will be worn near drill rigs.

Power Tools – All power tools will be inspected regularly (at least on a daily basis) and used in accordance with the manufacturer's instructions and its capabilities. Electrical tools will not be used in flammable areas, unless they are approved for that purpose. Portable electric tools will be used only with a GFCI. Proper hand, eye and hearing protection will be used when working with power tools and all appropriate safety guards must be in place. Personnel will be trained in the proper use of the specific tool. Any defective power tools will be immediately tagged and removed from service. Tools will be stored properly after use.

Pressurized Fluids/Gases – All compressed gases are hazardous due to the high pressures inside the cylinders. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder. Damaged cylinders can become projectiles resulting in severe injury and property damage. An unsecured or uncapped cylinder can become a cause of a major accident. Cylinders shall be secured when not in use, in transport, and as much as possible when in use.

Slips, Trips and Falls – Be aware of uneven ground and buried debris (e.g., metal, plastic, etc.) to avoid potential slip/trip/fall hazards, and use caution near open excavations. Maintain good housekeeping practices to minimize physical hazards.

Traffic Hazards – Driving to and from the site each day is considered a physical hazard. Directions and travel time to the site should be determined in advance (a.k.a. Journey Management Planning) and adequate time should be allocated to drive safely. The use of cellular phones is prohibited, and distracted driving should be avoided. Seatbelts shall be worn at all times while the vehicle is moving. Use caution around traffic flow. Ensure proper traffic control (e.g., signs, traffic cones, barriers, etc.) are in place prior to and throughout the work day where work takes place in or near traffic. Work personnel must wear ANSI-rated class 3 reflective traffic vests at all times. A site-specific traffic management plan describing procedures to be employed, including barriers, signage, etc., will be used for each drilling location.

Utilities – Dig Safely New York and non-member utilities must be notified at least 72 hours prior to commencing any intrusive activities. Use extreme caution when operating heavy equipment near utilities. Excavation and drilling locations will be selected that are located at safe distances from utility hazards. Prior to the operation of any heavy equipment, the site shall be inspected for potential overhead hazards (e.g., wires, tree branches, etc.). A minimum clearance of 10 feet must be maintained between equipment and overhead utility lines. If contact is possible (i.e., equipment, drill rig, excavator, etc.) one or more of the following will be done: 1) Power sources will be disconnected by the utility; 2) Power sources will be shielded by the utility; 3) Object will get no closer than 10 feet to prevent arcing, unless site specific conditions or weather conditions warrant greater separation per best professional judgment, or as directed by utility representatives; and, 3) Evaluate the need for shielding and coordinate with local utility representatives.

Weather – Heat and cold stress are a potential concern for on-site workers. Take breaks as needed to cool down, replenish fluids and/or warm up. Please refer to **Appendix D** for the signs, symptoms and precautions for cold and heat stress. Work may occur during a time of year when thunderstorms are possible/likely. If thunder or lightning is noted by onsite personnel, work will cease until the storm passes (thunder and/or lightning ceases and is not observed over at least a 30-minute period). Personnel will seek shelter in buildings or vehicles.

Working Over/Near Water – All workers working over/near water will be required to wear a Type I, II, or III Personal Floatation Device (PFD). When continuous fall protection is used (without exception) to prevent employees from falling into the water, the drowning hazard has effectively been removed. Therefore PFDs are not required when utilizing continuous fall protection.

5.3 Biological Hazards

[Add biological hazards to or delete biological hazards from the list below, as appropriate]

Biological Waste – This includes feces, urine, needles/sharps and other materials which may contain biological matter from humans or animals. This material should be avoided and not handled in any way. If biological waste impedes the planned scope of work the Project Manager or OSC should be contacted to discuss appropriate actions.

Blood-Borne Pathogens – Injuries received in the field may require assistance from a field team member with appropriate first aid/first responder training to perform first aid. Contact with blood and certain body fluids can contain pathogens that may be transmitted by contact with an open wound by the caregiver. The following precautions should be used when giving first aid:

- Use nitrile gloves to avoid contact with blood/fluids. Spent bandages and gloves used to perform first aid should be placed in a plastic bag and properly disposed.
- Blood/fluid should be cleaned from surfaces that may be contacted by other individuals.
- Use an appropriate barrier if required to perform rescue breathing.

Ticks - Ticks generally favor areas of high grass and dense vegetation so to the extent possible, these areas should be avoided. It is advisable when entering these areas to tuck pants into socks and to wear a light colored long sleeve shirt to help spot ticks before they bite. DEET-based insect repellents may be worn to repel ticks but hands should be washed thoroughly after use and DEET should not be sprayed directly onto the skin surface. Self-checks should be made frequently and at least at the end of the field day for ticks when working in or near vegetated areas.

If discovered, the tick should be removed with a pair of tweezers and saved in a sealed plastic bag. Sometimes, tick bites occur but the tick may not stay attached, followed by a rash developing in the area within a few days of the bite**. If bitten by a tick or a bulls-eye like rash develops, it is advisable to consult WorkCare**.

Spiders – Spiders typically seek cover in dark protected areas. Common areas where spiders may be encountered are heavy vegetation and trees. Spiders also are found in basements and enclosed spaces such as sheds, protective well covers, etc. Spider bites may cause swelling, pain and respiratory problems. Avoid dense vegetation, and use caution when sampling in dark poorly illuminated locations. If bitten, wash the area and use ice on the bite area to reduce swelling. If respiratory stress, significant pain or swelling is noted, or discoloration around the bite area occurs, seek immediate medical attention.

Stinging Insects – Like spiders, wasps and yellow jackets often nest in dense vegetation and in the ground, or in protective casings on monitoring wells and shielded gate locks. A sting from these insects can cause pain, swelling, and respiratory problems that may be life-threatening to certain individuals. If stung, remove stinger (if present) using tweezers, or similar, and wash the area and use ice on the sting area to reduce swelling. If respiratory stress, significant pain or swelling is noted, or discoloration around the sting area occurs, seek immediate medical attention.

Dogs and Wild Animals – Dogs often are not leashed and may be unfriendly. Bites from dogs and wild animals can cause infections or transmit disease. In general, it is best to not approach dogs even if they appear to be friendly, and wild animals should never be approached. If bitten, the area should be washed with soap and water. If the bite resulted in puncturing or tearing of the skin, the wound should be covered with a sterile dressing and medical attention should be sought immediately. A description of the dog should be noted and if possible, the dog's owner.

Plants – There are many types of plants which can cause irritation or allergic type reactions. Examples of some encountered on TRC sites include the following:

Poison Ivy **–** the trademarks of this plant are its solid green, pointed leaves that hang from the stem in groups of three. It grows as both a vine and a shrub. The look of poison ivy can change with the seasons. It produces yellow-green flowers in the spring and its green leaves can change to yellow and red in autumn.

Wild Parsnip/Giant Hogweed – Both plants are part of the carrot family and can grow up to 15 feet tall. They look similar to giant Queen Anne's lace with bristly stalks. Contact with the sap from the plant can cause phytophotodermatits or irritation (sometimes severe) when skin is exposed to sunlight.

<u>Pandemic Preparedness</u> – A "pandemic" refers to an epidemic that has spread over several countries or continents, usually impacting a large number of people. A pandemic has the potential to significantly impact routine services. A pandemic disease presents a serious health risk and could prevent TRC from performing project-related tasks. The risk to employee health and the business will vary based on the geographic area of the pandemic and the potential severity of the disease. Pandemic risk assessments will be performed by the TRC Corporate Safety team who will provide direction to field personnel.

TRC will follow health and travel precautions issued by the respective authorities. Employees should stay at home when sick or otherwise experience symptoms that are consistent with the pandemic disease. When at a project site, infection control measures should be enacted, which are essential components of pandemic management and a component of public health measures. These essential measures include:

- Practice frequent hand washing. According to the CDC, washing hands with soap and water is the best way to get rid of germs in most situations. If soap and water are not readily available, you can use an alcohol-based hand sanitizer that contains at least 60 percent alcohol. You can tell if the sanitizer contains at least 60 percent alcohol by looking at the product label.
- Obtain immunizations recommended by healthcare providers to help avoid disease.
- Practice social distancing to increase the space between employee work areas and decreasing the possibility of contact by limiting large or close contact gatherings and avoid shaking hands.
- Frequently disinfect all areas that are likely to have frequent hand contact (like doorknobs, faucets, handrails, etc.).

5.4 Radiological Hazards

[Add radiological hazards to or delete radiological hazards from the list below, as appropriate]

No radiological hazards are expected at the site. If any new condition is encountered during this activity, the HASP will be adjusted accordingly.

Radiation (ionizing) – Exposure to ionizing radiation can be controlled by one of three methods. Time, distance, or shielding. Limit your time near the radioactive source. Keep your distance from the radioactive source. Shield yourself from the radioactive source with appropriate shielding material. If the radioactive source(s) are from TRC equipment, the TRC employee using the equipment needs required training to use the equipment, and must be monitored using a dosimeter badge. Update contact information for TRC subject matter expertise and regulatory authorities.

X-Ray Fluorescence Instruments (a.k.a., XRF Guns) – XRF units for field metals analysis are only to be used by trained employees with radiation safety training. Licensing requirements can vary by state. Coordinate with the TRC Corporate Safety team before utilizing in the field to set up dosimetry protocols and instrument specific safety procedures.

6. Personal Protection Monitoring

Personal Protection Monitoring Equipment and Use Recommendations: The following table outlines monitoring equipment needs and rationale. Note that an upgrade to a higher level of respiratory protection (C or higher) will warrant revision or addendum to this HASP and consultation with the TRC Corporate Safety team before work recommences.

[Add/delete/modify Instruments, Use Codes, Action Levels and Notes/Rationale, as appropriate]

Table 2: Monitoring Equipment Use Recommendations

Instrument	Use Code	Action Levels	Notes/Rationale
PID	C	5 ppmv*	Recommended for VOC screening to monitor airborne VOC concentrations in breathing zone levels. If PID readings are sustained above 5 ppmv in the breathing zone for at least 5 minutes, move to an upwind location for 15 minutes. After 15 minutes, measure again. If PID readings are still above 5 ppmv in the breathing zone, contact the Project Manager or OSC to evaluate suitable response actions. Any upgrade in respiratory protection will be coordinated with the TRC Corporate Safety team. Withdraw from area if PID readings exceed 50 ppmv.
TSI Dustrak™ (or equivalent)	C	> 150 µg/m3; 15 minute average**	Used where contaminants could adhere to fugitive dust, and where fugitive dust migration could potentially serve as a significant exposure pathway. Half-faced APR for particulates to be used intermittently/temporarily where dust control measures cannot maintain dust levels below action level. Use is optional for dust levels below the action level. Use of a half-face APR for dust does not require CIH approval where dust action level excursions are limited in duration, and where

Table 2: Monitoring Equipment Use Recommendations			
Instrument	**Use Code**	**Action Levels**	**Notes/Rationale**
			dust control measures will be implemented until below the action level. However, personnel must be medically qualified, fit tested for half-face APR use, and trained in the use of the APR.
O^2/LEL	C	19.5%	Recommended for landfill, lagoon, excavation, sewer, and anaerobic degradation site work. Required for confined space work.
H_2S Meter	C	1 ppm	Recommended for landfill, lagoon, excavation, sewer, and anaerobic degradation site work. Required for confined space work.
CO	C	25 ppm	½ of the PEL (PEL = 50 ppm)
CGI	C	10% LEL	Recommended safe level to prevent explosive conditions.
MINIRAM (or equivalent)	O		Supplement operation of Dustrak™ stations for work near sensitive receptors.
Radiation meters	N/A		Not known or anticipated to be a Contaminant of Concern.
[Specify]	[Specify]	[Specify]	Coordinate all additional instrumentation with the OSC.

Notes:
* Site/project specific action levels for VOCs may be established in consultation with the OSC.
** Above background upwind levels
PID – Photoionization detector
H_2S – Hydrogen Sulfide
CGI – Combustible Gas Indicator
APR – Air Purifying Respirator
µg/m3 – micrograms per cubic meter
LEL – Lower Explosive Limit
CO – Carbon Monoxide
VOC – Volatile organic compound
CIH – Certified Industrial Hygienist
O_2 – Oxygen
ppm – Parts per Million
ppmv – Parts per Million Volume
PEL – Permissible Exposure Limit

Use Codes: R – Required, C – Condition specific, O – Optional, N/A – Not applicable

Personal Protection Monitoring Procedures: When necessary, the OHSO will measure organic vapor concentrations in the breathing zone using a PID. Fugitive dust emissions are not anticipated to be a concern. When required, air monitoring for dust will be performed using a combination of real-time dust monitoring upwind and downwind of the work area, and at a point near the closest receptor.

Personal Protection Exposure Limits: The following table summarizes anticipated concentrations and accepted exposure limits of chemicals potentially present within the work site.

[Add/delete/modify Chemical of Concern, Detected Concentrations, OSHA PEL/ACGIH TLV, On-Site Usage and Potential Exposures and Control Methods as appropriate]

Table 3: Summary of Exposure Limits – Known or Suspected Site Impacts		
Chemical of Concern	**Detected Concentration**	**OSHA PEL/ACGIH TLV**
Volatile Organic Compounds (VOCs)	Unknown	200 ppm (OSHA PEL for PCE) 200 ppm (OSHA PEL for TCE) 200 ppm (OSHA PEL for DCE)
Semi-volatile Organic Compounds (SVOCs)	Unknown	0.2 mg/m^3 (OSHA PEL for PAHs)
Polychlorinated Biphenyls (PCBs)	Unknown	1,000 µg/m^3 (OSHA PEL for PCBs containing 42% chlorine) 500 µg/m^3 (OSHA PEL for PCBs containing 54% chlorine)
Metals	Unknown	50 µg/m^3 (OSHA PEL for lead) 10 µg/m^3 (OSHA PEL for arsenic) 0.2 mg/m^3 (OSHA PEL for cadmium) 0.5 mg/m^3 (OSHA PEL for chromium) 0.2 mg/m^3 (OSHA PEL for selenium) 0.01 mg/m^3 (OSHA PEL for silver) 0.5 mg/m^3 (OSHA PEL for barium) 1.0 mg/10m^3 (OSHA PEL for mercury)
[Specify]	[Specify]	[Specify]

Notes: Exposure and hazard data obtained from the NIOSH Pocket Guide to Chemical Hazards unless otherwise noted.

ppm – parts per million
OSHA – Occupational Safety and Health Administration
PCE – Tetrachloroethene
DCE – Dichloroethene
µg/m3 – micrograms per cubic meter
TLV – Threshold Limit Value
PEL – Permissible Exposure Limit
TCE – Trichloroethelene
PAHs – Polycyclic aromatic hydrocarbons

Table 4: Preservatives and Decontamination Products		
Chemical of Concern	**On-Site Usage and Potential Exposures**	**Control Method**
Hydrochloric Acid (HCl)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample containerization.	5 ppm (OSHA PEL)
Methyl Alcohol (methanol; MeOH)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample	200 ppm (OSHA PEL)

Table 4: Preservatives and Decontamination Products		
Chemical of Concern	**On-Site Usage and Potential Exposures**	**Control Method**
	containerization.	
Nitric Acid (HNO_3)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample containerization.	5 mg/m3 (OSHA PEL)
Isobutylene	100 ppm gas for use during calibration of PID instruments.	No specific exposure limits for isobutylene (simple asphyxiant). Maintain oxygen levels above 19.5%. Before attaching regulator to cylinder, verify that the regulator is off. Before opening regulator, make sure that tubing connecting regulator to monitoring device/ Tedlar® bag is secure. To use a Tedlar® bag, put bag control valve in an open position and close after filling. Before disconnecting gas from the instrument and/or Tedlar® bag, verify the regulator is closed. Empty bag of contents after calibration in a downwind position and/or to avoid inadvertent inhalation.
Notes: ppm – parts per million ml – milliliters PID – Photoionization Detector OSHA – Occupational Safety and Health Administration PEL – Permissible Exposure Limit		

7. Personal Protective Equipment

[Add/delete/modify Item and Notes/Rationale, as appropriate]

TRC personnel will use Level D PPE as noted/modified below:

Table 5: Level D Personal Protective Equipment

Item	Rationale/Notes
Hardhat	American National Standards Institute/International Safety Equipment Association (ANSI/ISEA) Z89.1-2009 rated hard hats will be worn by personnel at all times when overhead hazards are present, including electrical.
Hearing protection	Hearing protection will be worn by all personnel exposed to at least 85 dB of sound during the workday. A good rule of thumb to use in determining whether background noise is 85 dB or higher is if you must shout to be understood by somebody about one arm-length away, that background noise is hazardous.
Safety boots (steel or composite toe and shank)	Electrical Hazard (EH) rated safety-toe safety boots will be worn by all personnel during project work described in this HASP.
Eye protection (safety glasses)	ANSI rated eye protection (Z87 or Z87+) is required to be worn at all times when onsite or when personnel are exposed to flying debris, chemical vapors or particulates. Chemical splash goggles will be worn for protection against chemical gases, vapors or particulates. Safety glasses will be worn for protection against flying objects.
Safety vest	ANSI Class 2 safety vest is required at all times when onsite. Utilize in areas in or near vehicular traffic of any kind on or off property.
Chemical Protective Clothing (CPC) and Gloves	CPC and gloves will be inspected according to TRC's Personal Protective Equipment Program. CPC will be chosen with assistance from the OSC according to the chemical hazards present. Gloves are to be changed between samples to avoid cross-contamination.
Cut resistant work gloves	As indicated herein, use Cut and Abrasion Resistance Level 2 to Level 4 gloves when necessary for hand protection during field tasks. See **Appendix B** for a Glove Selection Guide. ***Leather work gloves are expressly prohibited.***
Electrical Safety	8 cal/cm^2 Flame Resistant (FR) clothing
Personal Floatation Device (PFD)	Type I, II, or III PFD is required to be worn at all times when working over/near water.

A basic first aid kit will be readily available on-site in the event of an emergency.

Fire extinguishers should be present within 50 feet of wherever more than 5 gallons of flammable or combustible liquids or 5 pounds of flammable gas are being used at the site, including operational equipment. All personnel working on or around the equipment should know the location of and how to operate the fire extinguisher. Ensure the fire extinguisher is in working order by checking the manufacture and/or most recent inspection dates.

8. Personnel and Equipment Decontamination Plan

At minimum, personnel and equipment decontamination will include the following:

Equipment Decontamination: There is a possibility that site media contacted during work activities contain compounds described in **Table 3**. All equipment that comes in contact with media needs to be decontaminated before it is removed from the job site. To properly decontaminate equipment that comes in contact with media, the following procedure should be followed:

- Brush accumulated material off equipment that has come in contact with impacted media. The material shall be returned to the location from which it came or disposed of properly;
- Wipe parts of the equipment that came in contact with the media down with cloth, rags or heavy-duty paper towel damp with non-phosphate concentrated laboratory-grade soap (i.e. Alconox© or Liquinox©);
- Follow up with a wipe from a separate cloth, rags or heavy duty paper towel damp with potable water; and
- PPE and cloth, rags or heavy duty paper towels can be disposed of in the regular waste stream.
- If equipment becomes grossly impacted with site media, equipment shall be steam cleaned over a decontamination pad.

Personnel Decontamination: In general, contamination of personnel shall be prevented through the use of PPE. At minimum, nitrile gloves shall be worn during contact with impacted material or chemical in addition to other Level D PPE.

9. Required Personnel Training

TRC field personnel will have the training outlined below before on-site work activities:

Table 6: Project Training Requirements

(* required for all sites; but minimum recommended)
Check "A" if training required for everyone, and check "T" if training required for specific task or per notations.

A	T	Subject	Reference: 29 CFR 1910	Reference: 29 CFR 1926 or Other
☒	☐	HAZWOPER 40 hour*	1910.120	1926.65
☒	☐	3-Day HAZWOPER Supervised On-site*	1910.120	1926.65
☒	☐	8-Hour HAZWOPER Refresher*	1910.120	1926.65
☐	☒	8-Hour Supervisor HAZWOPER*	1910.120	1926.65
☐	☒	First Aid, CPR*[,1]	1910.151	1926.23,.50
☒	☐	Hazard Communication (HAZCOM)	1910.1200	1926.59
☐	☒	DOT/IATA Shipping Training	1910.1201	49 CFR 172.704
☐	☐			
☐	☐			
☐	☐			

Client-specific training:_______________ ☐ Not Applicable ☐ Specify
Client-specific training:_______________ ☐ Not Applicable ☐ Specify
Client-specific training:_______________ ☐ Not Applicable ☐ Specify

Note:
1 Per the TRC Health and Safety Policy and Procedure Manual, each TRC project will have at least one certified CPR/first aid trained person on site at all times. All Project Managers and anyone acting as the on-site Health and Safety Officer must be current in First Aid/CPR.

Project training requirements beyond those provided in the above table will require a HASP revision/upgrade or concurrence of the TRC Safety Director or ECR Safety Manager.

10. Medical Monitoring

Medical monitoring will apply routinely to all employees who are or may be exposed to hazardous substances or health hazards at or above the established permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year (40 CFR 1910.120[f][2][i]). Said TRC field personnel will have the medical surveillance outlined in the table below prior to commencing on-site work activities.

Table 7: Medical Surveillance Required			
*Baseline is minimum recommended.			
	29 CFR 1910	**29 CFR 1926 or Other**	**Notes**
☒ HAZWOPER Physical - Baseline*	1910.120	1926.65	
☒ HAZWOPER Physical – Annual	1910.120	1926.65	
☐ HAZWOPER Physical - Biennial*	1910.120	1926.65	
Client-specific drug testing[1]	☐ Not Applicable	☐ Specify	
Client-specific medical monitoring[1]	☐ Not Applicable	☐ Specify	
Site-specific medical monitoring:	☐ Not Applicable	☐ Specify	
Note: [1] Client required drug testing or medical monitoring should be coordinated through the Project Manager.			

TRC has a Drug and Alcohol-Free Workplace Policy (TRC Academy Course #900013753). TRC may require employees or subcontractors to be tested upon reasonable suspicion, following accidents or incidents during work activities, or during travel to or from a project site. Client policies may be stricter in regard to procedures following an accident. Project Managers must be aware of these and inform employees and subcontractors of any additional requirements.

11. General Safety Requirements

The general safety rules listed below apply to all TRC personnel present at the site.

- A tailgate health and safety meeting will be held with all field team members each day prior to the start of work, the start of a new shift, upon changing of work conditions or job task duties, or when new field team members arrive onsite.
- Adhere to all requirements of this HASP.
- Wear protective clothing appropriate for the designated level of protection and decontaminate before entering clean areas when applicable.
- Use safety equipment in accordance with OSHA guidance and labeling instructions.
- Maintain safety equipment in good condition and proper working order and make sure that the equipment is calibrated prior to use.
- Immediately report unsafe acts or conditions to the Project Manager and OSC.
- Eating, drinking, and smoking are prohibited on site, except in designated areas.
- Maintaining a position upwind from intrusive activities is encouraged.
- The emergency shutoff switch should be demonstrated to be working prior to initiating drilling.
- An adequately stocked first-aid kit will be maintained at the work site.

12. Tailgate Safety Meetings

- A tailgate safety meeting will be conducted daily prior to commencement of the work day, the start of a new shift, upon changing of work conditions or job task duties, or when new field team members arrive onsite (see checklist provided in **Appendix E**).

- Topics covered by the tailgate safety meeting will include, but not be limited to, scope of work and who will conduct each task, potential hazards, weather forecast, PPE, emergency procedures and the route to the medical facility, site conditions and features, and, communication guidelines related to stakeholder engagement and visitors.
- Safety meetings must also be held to address modifications to this HASP and any addenda prepared to supplement the HASP.
- Subcontractors and personnel present at the tailgate safety meeting shall be required to sign an acknowledgement form after each meeting.

13. Emergency/Contingency Plan

Before commencing any on-site operations, the TRC OHSO will advise all personnel of potential emergencies. Personnel will be advised on their roles in the event of an emergency, and the steps to take for a timely and controlled response.

Communication networks/chain of command – All on-site personnel will communicate any accident, injury or near miss to the TRC OHSO who will provide instruction on how to proceed further.

First Aid / Safety Equipment – First aid equipment should be readily available in the event of an emergency. First aid equipment should include a well-stocked first aid kit, fire extinguisher and emergency eye wash.

Evacuation Plans and Refuge Area – All personnel should safely remove themselves from danger in the event of an emergency and safely access the refuge area. The refuge area should be in an upwind location a safe distance from the work zone. The refuge area will be determined during the daily safety briefing.

Notifications of Fire, Police and Emergency Facilities – In the event of an emergency that cannot be controlled by on-site personnel, the appropriate emergency contact shall be notified. All personnel shall remove themselves from the area of danger and wait for the arrival of help in the predetermined refuge area.

Non-Emergency Medical Assistance – If an injury does occur and it is not life threatening, then the employee or employee's supervisor/project manager should contact WorkCare as soon as possible, but within the first hour after an injury. WorkCare information is proved in **Appendix F**. This information will help assist the injured employee by connecting them with instant access to a medically qualified professional in order to provide guidance on appropriate first aid measures and medications.

14. Stop Work

TRC personnel are all empowered, responsible, authorized and obliged to stop work at any time we feel that our safety or the safety of others is, or could be, compromised. When a stop work occurs the Project Manager and/or OSC should be contacted to discuss the reason for the stop work and the corrective action(s) needed to resume work safely. Work on an activity shall not continue until the unsafe condition has been corrected.

15. Safe Catches

A "Safe Catch" is a potential hazard or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries. It is everyone's responsibility to report and/or correct these potential incidents immediately. Please complete the form provided in **Appendix G** as a means to report these "Safe Catch" situations and submit to your local OSC Representative and Mike Glenn, National Safety Director.

16. Observations

Note that the Project Manager and/or OSC may notify field staff that their site activities may be the subject of Safety Observation, an integral part of the continuous improvement safety culture promoted at TRC. If subject to an observation, please note the following:

- The Observation will tend to focus on the highest risk activity (as a general example, drilling in a public right-of-way).
- Follow-up observations may need to occur on previous observations, depending on prior data collected.
- The observer's preparation before visiting the site will be a review of the HASP, JSAs, client-specific requirements, etc., and a review of the work scope with the Project Manager to ensure the context of the work is well understood in advance.
- Review items may include PPE, body use and positioning, work environment, operating procedures, and tools and equipment.
- The observation should last between 30 and 60 minutes.

Both positive and negative observations are candidates for documentation and later discussion. The overarching goals are to identify and correct questionable practices and to identify and promote good, safe and efficient practices. It is a data gathering process that will allow TRC safety specialists to identify root causes for safety issues in both categories to better inform policy decisions.

17. Incident Reporting

In case of an incident, TRC personnel must report the incident immediately to their project manager/supervisor and/or OSC as well as the client's representative and follow the TRC Incident Response and Reporting Process (see **Appendix H -** In Case of Emergency and Incident Reporting). Required Incident Notification or Auto Incident Report forms must be completed within 24 hours following the incident. If neither is available, the incident shall be reported to the TRC Safety Director. Incident/injury/exposure information must be recorded per TRC policy and will be the basis of any incident investigations.

18. Job Safety Analysis

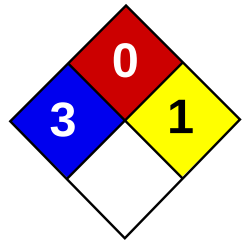
It is anticipated that the standard operating procedures (SOPs) detailed in the Generic Field Activities Plan (FAP) will be utilized for all work practices. If site specific activities require additional or alternate procedures, TRC will assess the task hazards and controls using separate job safety analysis forms (JSAs). Prior to use in the field, JSAs will be reviewed and approved by the TRC Project Manager and OSC. JSA forms can be found in **Appendix I**.

19. Acknowledgement

All TRC personnel operating under this HASP must read the HASP and sign the acknowledgment page in **Appendix J**.

Figure 1
Site Layout

Appendix A
Safety Data Sheets



Health	3
Fire	0
Reactivity	1
Personal Protection	

Material Safety Data Sheet
Hydrochloric acid MSDS

Section 1: Chemical Product and Company Identification

Product Name: Hydrochloric acid

Catalog Codes: SLH1462, SLH3154

CAS#: Mixture.

RTECS: MW4025000

TSCA: TSCA 8(b) inventory: Hydrochloric acid

CI#: Not applicable.

Synonym: Hydrochloric Acid; Muriatic Acid

Chemical Name: Not applicable.

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Hydrogen chloride	7647-01-0	20-38
Water	7732-18-5	62-80

Toxicological Data on Ingredients: Hydrogen chloride: GAS (LC50): Acute: 4701 ppm 0.5 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, . Slightly hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth. Repeated or prolonged exposure to the substance can produce target

organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: of metals

Explosion Hazards in Presence of Various Substances: Non-explosive in presence of open flames and sparks, of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards:
Non combustible. Calcium carbide reacts with hydrogen chloride gas with incandescence. Uranium phosphide reacts with hydrochloric acid to release spontaneously flammable phosphine. Rubidium acetylene carbides burns with slightly warm hydrochloric acid. Lithium silicide in contact with hydrogen chloride becomes incandescent. When dilute hydrochloric acid is used, gas spontaneously flammable in air is evolved. Magnesium boride treated with concentrated hydrochloric acid produces spontaneously flammble gas. Cesium acetylene carbide burns hydrogen chloride gas. Cesium carbide ignites in contact with hydrochloric acid unless acid is dilute. Reacts with most metals to produce flammable Hydrodgen gas.

Special Remarks on Explosion Hazards:

Hydrogen chloride in contact with the following can cause an explosion, ignition on contact, or other violent/vigorous reaction: Acetic anhydride AgClO + CCl4 Alcohols + hydrogen cyanide, Aluminum Aluminum-titanium alloys (with HCl vapor), 2-Amino ethanol, Ammonium hydroxide, Calcium carbide Ca3P2 Chlorine + dinitroanilines (evolves gas), Chlorosulfonic acid Cesium carbide Cesium acetylene carbide, 1,1-Difluoroethylene Ethylene diamine Ethylene imine, Fluorine, HClO4 Hexalithium disilicide H2SO4 Metal acetylides or carbides, Magnesium boride, Mercuric sulfate, Oleum, Potassium permanganate, beta-Propiolactone Propylene oxide Rubidium carbide, Rubidium, acetylene carbide Sodium (with aqueous HCl), Sodium hydroxide Sodium tetraselenium, Sulfonic acid, Tetraselenium tetranitride, U3P4 , Vinyl acetate. Silver perchlorate with carbon tetrachloride in the presence of hydrochloric acid produces trichloromethyl perchlorate which detonates at 40 deg. C.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, organic materials, metals, alkalis, moisture. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
CEIL: 5 (ppm) from OSHA (PEL) [United States] CEIL: 7 (mg/m3) from OSHA (PEL) [United States] CEIL: 5 from NIOSH CEIL: 7 (mg/m3) from NIOSH TWA: 1 STEL: 5 (ppm) [United Kingdom (UK)] TWA: 2 STEL: 8 (mg/m3) [United Kingdom (UK)]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Pungent. Irritating (Strong.)

Taste: Not available.

Molecular Weight: Not applicable.

Color: Colorless to light yellow.

pH (1% soln/water): Acidic.

Boiling Point:
108.58 C @ 760 mm Hg (for 20.22% HCl in water) 83 C @ 760 mm Hg (for 31% HCl in water) 50.5 C (for 37% HCl in water)

Melting Point:
-62.25°C (-80°F) (20.69% HCl in water) -46.2 C (31.24% HCl in water) -25.4 C (39.17% HCl in water)

Critical Temperature: Not available.

Specific Gravity:
1.1- 1.19 (Water = 1) 1.10 (20%and 22% HCl solutions) 1.12 (24% HCl solution) 1.15 (29.57% HCl solution) 1.16 (32% HCl solution) 1.19 (37% and 38%HCl solutions)

Vapor Pressure: 16 kPa (@ 20°C) average

Vapor Density: 1.267 (Air = 1)

Volatility: Not available.

Odor Threshold: 0.25 to 10 ppm

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether.

Solubility: Soluble in cold water, hot water, diethyl ether.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, water

Incompatibility with various substances:
Highly reactive with metals. Reactive with oxidizing agents, organic materials, alkalis, water.

Corrosivity:
Extremely corrosive in presence of aluminum, of copper, of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts with water especially when water is added to the product. Absorption of gaseous hydrogen chloride on mercuric sulfate becomes violent @ 125 deg. C. Sodium reacts very violently with gaseous hydrogen chloride. Calcium phosphide and hydrochloric acid undergo very energetic reaction. It reacts with oxidizers releasing chlorine gas. Incompatible with, alkali metals, carbides, borides, metal oxides, vinyl acetate, acetylides, sulphides, phosphides, cyanides, carbonates. Reacts with most metals to produce flammable Hydrogen gas. Reacts violently (moderate reaction with heat of evolution) with water especially when water is added to the product. Isolate hydrogen chloride from heat, direct sunlight, alkalies (reacts vigorously), organic materials, and oxidizers (especially nitric acid and chlorates), amines, metals, copper and alloys (e.g. brass), hydroxides, zinc (galvanized materials), lithium silicide (incandescence), sulfuric acid(increase in temperature and pressure) Hydrogen chloride gas is emitted when this product is in contact with sulfuric acid. Adsorption of Hydrochloric Acid onto silicon dioxide results in exothmeric reaction. Hydrogen chloride causes aldehydes and epoxides to violently polymerize. Hydrogen chloride or Hydrochloric Acid in contact with the folloiwng can cause explosion or ignition on contact or

Special Remarks on Corrosivity:

Highly corrosive. Incompatible with copper and copper alloys. It attacks nearly all metals (mercury, gold, platinium, tantalum, silver, and certain alloys are exceptions). It is one of the most corrosive of the nonoxidizing acids in contact with copper alloys. No corrosivity data on zinc, steel. Severe Corrosive effect on brass and bronze

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
Acute oral toxicity (LD50): 900 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 1108 ppm, 1 hours [Mouse]. Acute toxicity of the vapor (LC50): 3124 ppm, 1 hours [Rat].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. May cause damage to the following organs: kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of ingestion, . Hazardous in case of eye contact (corrosive), of inhalation (lung corrosive).

Special Remarks on Toxicity to Animals:
Lowest Published Lethal Doses (LDL/LCL) LDL [Man] -Route: Oral; 2857 ug/kg LCL [Human] - Route: Inhalation; Dose: 1300 ppm/30M LCL [Rabbit] - Route: Inhalation; Dose: 4413 ppm/30M

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (fetoxicity). May affect genetic material.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Corrosive. Causes severe skin irritation and burns. Eyes: Corrosive. Causes severe eye irritation/conjuntivitis, burns, corneal necrosis. Inhalation: May be fatal if inhaled. Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Inhalation of hydrochloric acid fumes produces nose, throat, and larryngeal burning, and irritation, pain and inflammation, coughing, sneezing, choking sensation, hoarseness, laryngeal spasms, upper respiratory tract edema, chest pains, as well has headache, and palpitations. Inhalation of high concentrations can result in corrosive burns, necrosis of bronchial epithelium, constriction of the larynx and bronchi, nasospetal perforation, glottal closure, occur, particularly if exposure is prolonged. May affect the liver. Ingestion: May be fatal if swallowed. Causes irritation and burning, ulceration, or perforation of the gastrointestinal tract and resultant peritonitis, gastric hemorrhage and infection. Can also cause nausea, vomitting (with "coffee ground" emesis), diarrhea, thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (esophogeal, gastric, pyloric). May affect behavior (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system (kidneys- renal failure, nephritis). Acute exposure via inhalation or ingestion can also cause erosion of tooth enamel. Chronic Potential Health Effects: dyspnea, bronchitis. Chemical pneumonitis and pulmonary edema can also

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Hydrochloric acid, solution UNNA: 1789 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Hydrochloric acid Illinois toxic substances disclosure to employee act: Hydrochloric acid Illinois chemical safety act: Hydrochloric acid New York release reporting list: Hydrochloric acid Rhode Island RTK hazardous substances: Hydrochloric acid Pennsylvania RTK: Hydrochloric acid Minnesota: Hydrochloric acid Massachusetts RTK: Hydrochloric acid Massachusetts spill list: Hydrochloric acid New Jersey: Hydrochloric acid New Jersey spill list: Hydrochloric acid Louisiana RTK reporting list: Hydrochloric acid Louisiana spill reporting: Hydrochloric acid California Director's List of Hazardous Substances: Hydrochloric acid TSCA 8(b) inventory: Hydrochloric acid TSCA 4(a) proposed test rules: Hydrochloric acid SARA 302/304/311/312 extremely hazardous substances: Hydrochloric acid SARA 313 toxic chemical notification and release reporting: Hydrochloric acid CERCLA: Hazardous substances.: Hydrochloric acid: 5000 lbs. (2268 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):
R34- Causes burns. R37- Irritating to respiratory system. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

- **Health Hazard:** 3
- **Fire Hazard:** 0
- **Reactivity:** 1
- **Personal Protection:**

National Fire Protection Association (U.S.A.):

- **Health:** 3
- **Flammability:** 0
- **Reactivity:** 1
- **Specific hazard:**

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Guide de la loi et du règlement sur le transport des marchandises dangeureuses au canada. Centre de conformité internatinal Ltée. 1986.

Other Special Considerations: Not available.

Created: 10/09/2005 05:45 PM

Last Updated: 06/09/2012 12:00 PM

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

MSDS NO: 248 **Version:3** **Date: August, 2010**

1. Chemical Product and Company Identification

Gasco Affiliates, LLC
320 Scarlett Blvd.
Oldsmar, FL 34677

TELEPHONE NUMBER: (800) 910-0051 **24-HOUR EMERGENCY NUMBER: 1-800-424-9300**
FAX NUMBER: (866) 755-8920
E-MAIL: info@gascogas.com

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR
CHEMICAL NAME: Isobutylene in air
COMMON NAMES/ SYNONYMS: None
TDG (Canada) CLASSIFICATION: 2.2
WHIMIS CLASSIFICATION: A

2. COMPOSITION/ INFORMATION ON INGREDIENTS

INGREDIENT	%VOLUME	PEL-OSHA	TLV-ACGIH	LD_{50} or LC_{50} Route/Species
Isobutylene FORMULA: C_4H_8	0.0001-0.9	N/A	N/A	N/A
Air FORMULA: Mixture	99.0 to 99.9999	N/A	N/A	N/A

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Release of this product may produce oxygen-deficient atmospheres (especially in confined spaces or other poorly ventilated environments); individuals in such atmospheres may be asphyxiated. Isobutylene may cause drowsiness and other central nervous system effects in high concentrations; however, due to the low concentration of this gas mixture, this is unlikely to occur.

ROUTE OF ENTRY:

Skin Contact	Skin Absorption	Eye Contact	Inhalation	Ingestion
No	No	No	Yes	No

HEALTH EFFECTS:

Exposure Limits	Irritant	Sensitization	Reproductive Hazard	Mutagen
Yes	No	No	No	No

Carcinogenicity: --NTP: No IARC: No OSHA: No

EYE EFFECTS:
N/A.

SKIN EFFECTS:
N/A.

GASCO

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

INGESTION EFFECTS:
Ingestion unlikely. Gas at room temperature.

INHALATION EFFECTS:
Due to the small size of this cylinder, no unusual health effects from over-exposure are anticipated under normal routine use.

NFPA HAZARD CODES		HMIS HAZARD CODES		RATING SYSTEM
Health:	1	Health:	1	0= No Hazard
Flammability:	0	Flammability:	0	1= Slight Hazard
Reactivity:	0	Reactivity:	0	2= Moderate Hazard
				3= Serious Hazard
				4= Severe Hazard

4. FIRST AID MEASURES

EYES:
N/A

SKIN:
N/A

INGESTION:
Not required

INHALATION:
PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASED OF OVEREXPOSURE. RESCUE PERSONNEL SHOULD BE EQUIPPED THE SELF-CONTAINED BREATHING APPARATUS. Victims should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. If breathing has stopped administer artificial resuscitation and supplemental oxygen. Further treatment should be symptomatic and supportive.

5. FIRE-FIGHTING MEASURES

These containers hold gas under pressure, with no liquid phase. If involved in a major fire, they should be sprayed with water to avoid pressure increases, otherwise pressures will rise and ultimately they may distort or burst to release the contents. The gases will not add significantly to the fire, but containers or fragments may be projected considerable distances - thereby hampering fire fighting efforts.

6. ACCIDENTAL RELEASE MEASURES

In terms of weight, these containers hold very little contents, such that any accidental release by puncturing etc. will be of no practical concern.

7. HANDLING AND STORAGE

Suck back of water into the container must be prevented. Do not allow backfeed into the container. Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Use only in well-ventilated areas. Do not heat cylinder by any means to increase rate of product from the cylinder. Do not allow the temperature where cylinders are stored to exceed 130^{o}F (54^{o}C).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Use adequate ventilation for extended use of gas.

GASCO

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

9. PHYSICAL AND CHEMICAL PROPERTIES

PARAMETER:	VALUE:
Physical state	: Gas
Evaporation point	: N/A
pH	: N/A
Odor and appearance	: Colorless, odorless gas

10. STABILITY AND REACTIVITY

Stable under normal conditions. Expected shelf life 48 months.

11. TOXICOLOGICAL INFORMATION

No toxicological damage caused by this product.

12. ECOLOGICAL INFORMATION

No ecological damage caused by this product.

13. DISPOSAL INFORMATION

Do not discharge into any place where its accumulation could be dangerous. Used containers are acceptable for disposal in the normal waste stream as long as the cylinder is empty and valve removed or cylinder wall is punctured; but GASCO encourages the consumer to return cylinders.

14. TRANSPORT INFORMATION

	United States DOT	Canada TDG
PROPER SHIPPING NAME:	Compressed Gas N.O.S. (Isobutylene in Air)	Compressed Gas N.O.S. (Isobutylene in Air)
HAZARD CLASS:	2.2	2.2
IDENTIFICATION NUMBER:	UN1956	UN1956
SHIPPING LABEL:	NONFLAMMABLE GAS	NONFLAMMABLE GAS

15. REGULATORY INFORMATION

Isobutylene is listed under the accident prevention provisions of section 112(r) of the Clean Air Act (CAA) with a threshold quantity (TQ) of 10,000 pounds.

16. OTHER INFORMATION

This MSDS has been prepared in accordance with the Chemicals (Hazard Information and Packaging for Supply (Amendment) Regulation 1996. The information is based on the best knowledge of GASCO, and its advisors and is given in good faith, but we cannot guarantee its accuracy, reliability or completeness and therefore disclaim any liability for loss or damage arising out of use of this data. Since conditions of use are outside the control of the Company and its advisors we disclaim any liability for loss or damage when the product is used for other purposes than it is intended.

MSDS/S010/248/ August, 2010

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017

Trade Name: Alconox

1 Identification of the substance/mixture and of the supplier

1.1 Product identifier

Trade Name: Alconox

Synonyms:

Product number: 1104-1, 1104, 1125, 1150, 1101, 1103, 1112-1, 1112

1.2 Application of the substance / the mixture : Cleaning material/Detergent

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer **Supplier**

Alconox, Inc.
30 Glenn Street
White Plains, NY 10603
1-914-948-4040

Emergency telephone number:

ChemTel Inc

North America: 1-800-255-3924
International: 01-813-248-0585

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments.

Hazard-determining components of labeling:

Tetrasodium Pyrophosphate
Sodium tripolyphosphate
Sodium Alkylbenzene Sulfonate

2.2 Label elements:

Skin irritation, category 2.
Eye irritation, category 2A.

Hazard pictograms:

Signal word: Warning

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P321 Specific treatment (see supplemental first aid instructions on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P501 Dispose of contents and container as instructed in Section 13.

Additional information: None.

Hazard description

Hazards Not Otherwise Classified (HNOC): None

Information concerning particular hazards for humans and environment:

The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:

The classification is according to EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments, and extended by company and literature data. The classification is in accordance with the latest editions of international substances lists, and is supplemented by information from technical literature and by information provided by the company.

3 Composition/information on ingredients

3.1 Chemical characterization : None

3.2 Description : None

3.3 Hazardous components (percentages by weight)

Identification	Chemical Name	Classification	Wt. %
CAS number: 7758-29-4	Sodium tripolyphosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	12-28
CAS number: 68081-81-2	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	8-22
CAS number: 7722-88-5	Tetrasodium Pyrophosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	2-16

3.4 Additional Information : None.

4 First aid measures

4.1 Description of first aid measures

General information: None.

After inhalation:

Maintain an unobstructed airway.
Loosen clothing as necessary and position individual in a comfortable position.

After skin contact:

Wash affected area with soap and water.
Seek medical attention if symptoms develop or persist.

After eye contact:

Rinse/flush exposed eye(s) gently using water for 15-20 minutes.
Remove contact lens(es) if able to do so during rinsing.
Seek medical attention if irritation persists or if concerned.

After swallowing:

Rinse mouth thoroughly.
Seek medical attention if irritation, discomfort, or vomiting persists.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017
Trade Name: Alconox

4.2 Most important symptoms and effects, both acute and delayed

None

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information.

5 Firefighting measures

5.1 Extinguishing media

Suitable extinguishing agents:
Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition.

For safety reasons unsuitable extinguishing agents : None

5.2 Special hazards arising from the substance or mixture :
Thermal decomposition can lead to release of irritating gases and vapors.

5.3 Advice for firefighters

Protective equipment:
Wear protective eye wear, gloves and clothing.
Refer to Section 8.

5.4 Additional information :
Avoid inhaling gases, fumes, dust, mist, vapor and aerosols.
Avoid contact with skin, eyes and clothing.

6 Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures :
Ensure adequate ventilation.
Ensure air handling systems are operational.

6.2 Environmental precautions :
Should not be released into the environment.
Prevent from reaching drains, sewer or waterway.

6.3 Methods and material for containment and cleaning up :
Wear protective eye wear, gloves and clothing.

6.4 Reference to other sections : None

7 Handling and storage

7.1 Precautions for safe handling :
Avoid breathing mist or vapor.
Do not eat, drink, smoke or use personal products when handling chemical substances.

7.2 Conditions for safe storage, including any incompatibilities :
Store in a cool, well-ventilated area.

7.3 Specific end use(s):

No additional information.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017

Trade Name: Alconox

8 Exposure controls/personal protection

8.1 Control parameters :

a) 7722-88-5, Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3

b) Dusts, non-specific OEL, Irish Code of Practice

(i) Total inhalable 10 mg/m3 (8hr)

(ii) Respirible 4mg/m3 (8hr)

(iii) Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3, (8hr)

8.2 Exposure controls

Appropriate engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use or handling.

Respiratory protection:

Not needed under normal use conditions.

Protection of skin:

Select glove material impermeable and resistant to the substance or preparation. Protective gloves recommended to comply with EN 374. Take note of break through times, permeability, and special workplace conditions, such as mechanical strain, duration of contact, etc. Protective gloves should be replaced at the first sign of wear.

Eye protection:

Safety goggles or glasses, or appropriate eye protection. Recommended to comply with ANSI Z87.1 and/or EN 166.

General hygienic measures:

Wash hands before breaks and at the end of work.

Avoid contact with skin, eyes and clothing.

9 Physical and chemical properties

Appearance (physical state, color):	White and cream colored flakes - powder	**Explosion limit lower**: **Explosion limit upper**:	Not determined or not available. Not determined or not available.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or not available.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or not available.
pH-value:	9.5 (aqueous solution)	**Relative density**:	Not determined or not available.
Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or not available.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or not available.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or not available.
Evaporation rate:	Not determined or not available.	**Decompositio n**	Not determined or not available.

Flammability (solid, gaseous):	Not determined or not available.	**Viscosity**:	a. Kinematic: Not determined or not available. b. Dynamic: Not determined or not available.
Density at 20°C:	Not determined or not available.		

10 Stability and reactivity

10.1 Reactivity : None

10.2 Chemical stability : None

10.3 Possibility hazardous reactions : None

10.4 Conditions to avoid : None

10.5 Incompatible materials : None

10.6 Hazardous decomposition products : None

11 Toxicological information

11.1 Information on toxicological effects :

Acute Toxicity:

Oral:

: LD50 > 5000 mg/kg oral rat - Product .

Chronic Toxicity: No additional information.

Skin corrosion/irritation:

Sodium Alkylbenzene Sulfonate: Causes skin irritation. .

Serious eye damage/irritation:

Sodium Alkylbenzene Sulfonate: Causes serious eye irritation .

Tetrasodium Pyrophosphate: Rabbit - Risk of serious damage to eyes .

Respiratory or skin sensitization: No additional information.

Carcinogenicity: No additional information.

IARC (International Agency for Research on Cancer): None of the ingredients are listed.

NTP (National Toxicology Program): None of the ingredients are listed.

Germ cell mutagenicity: No additional information.

Reproductive toxicity: No additional information.

STOT-single and repeated exposure: No additional information.

Additional toxicological information: No additional information.

12 Ecological information

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.
Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.4 mg/l, 48 hours. Sodium Alkylbenzene Sulfonate: Aquatic Plants, EC50 Algae 29 mg/l, 96 hours.
Tetrasodium Pyrophosphate: Fish, LC50 - other fish - 1,380 mg/l - 96 h.
Tetrasodium Pyrophosphate: Aquatic invertebrates, EC50 - Daphnia magna (Water flea) - 391 mg/l - 48 h.

12.2 Persistence and degradability: No additional information.

12.3 Bioaccumulative potential: No additional information.

12.4 Mobility in soil: No additional information.

General notes: No additional information.

12.5 Results of PBT and vPvB assessment:

PBT: No additional information.

vPvB: No additional information.

12.6 Other adverse effects: No additional information.

13 Disposal considerations

13.1 Waste treatment methods (consult local, regional and national authorities for proper disposal)

Relevant Information:

It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities. (US 40CFR262.11).

14 Transport information

14.1 UN Number: ADR, ADN, DOT, IMDG, IATA	None
14.2 UN Proper shipping name: ADR, ADN, DOT, IMDG, IATA	None
14.3 Transport hazard classes: ADR, ADN, DOT, IMDG, IATA	**Class:** None **Label:** None **LTD. QTY:** None

US DOT
Limited Quantity Exception: None

Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.

Non Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.

	Comments: None	**Comments:** None
14.4	**Packing group:** ADR, ADN, DOT, IMDG, IATA	None
14.5	**Environmental hazards** :	None
14.6	**Special precautions for user:**	None
	Danger code (Kemler):	None
	EMS number:	None
	Segregation groups:	None
14.7	**Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code:** Not applicable.	
14.8	**Transport/Additional information:**	
	Transport category:	None
	Tunnel restriction code:	None
	UN "Model Regulation":	None

15 Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture.

North American

SARA

Section 313 (specific toxic chemical listings): None of the ingredients are listed.
Section 302 (extremely hazardous substances): None of the ingredients are listed.

CERCLA (Comprehensive Environmental Response, Clean up and Liability Act) Reportable Spill Quantity: None of the ingredients are listed.

TSCA (Toxic Substances Control Act):

Inventory: All ingredients are listed.
Rules and Orders: Not applicable.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredients are listed.

Chemicals known to cause developmental toxicity: None of the ingredients are listed.

Canadian

Canadian Domestic Substances List (DSL):
All ingredients are listed.

EU

REACH Article 57 (SVHC): None of the ingredients are listed.

Germany MAK: Not classified.
EC 648/2004 – This is an industrial detergent. Contains >30% phosphate, 15-30% anionic surfactant, <5% EDTA salts
EC 551/2009 – This is not a laundry or dishwasher detergent
EC 907/2006 – Contains no enzymes, optical brighteners, perfumes, allergenic fragrances, or preservative agents

Asia Pacific

Australia

Australian Inventory of Chemical Substances (AICS): All ingredients are listed.

China

Inventory of Existing Chemical Substances in China (IECSC): All ingredients are listed.

Japan

Inventory of Existing and New Chemical Substances (ENCS): All ingredients are listed.

Korea

Existing Chemicals List (ECL): All ingredients are listed.

New Zealand

New Zealand Inventory of Chemicals (NZOIC): All ingredients are listed.

Philippines

Philippine Inventory of Chemicals and Chemical Substances (PICCS): All ingredients are listed.

Taiwan

Taiwan Chemical Substance Inventory (TSCI): All ingredients are listed.

16 Other information

Abbreviations and Acronyms: None

Summary of Phrases

Hazard statements:
H315 Causes skin irritation.
H319 Causes serious eye irritation.

NFPA: 1-0-0
HMIS: 1-0-0

Precautionary statements:
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P321 Specific treatment (see supplemental first aid instructions on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P501 Dispose of contents and container as instructed in Section 13.

Manufacturer Statement:

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

1 Identification of the substance/mixture and of the supplier

1.1 Product identifier

Trade Name: Liquinox
Synonyms:
Product number: 1232-1, 1232, 1201-1, 1201, 1205, 1215, 1255

1.2 Application of the substance / the mixture : Cleaning material/Detergent

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer	**Supplier**
Alconox, Inc. 30 Glenn Street White Plains, NY 10603 1-914-948-4040	

Emergency telephone number:
ChemTel Inc
North America: 1-800-255-3924
International: 01-813-248-0585

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments.

Hazard-determining components of labeling:
Alcohol ethoxylate
Sodium alkylbenzene sulfonate
Sodium xylenesulphonate
Lauramine oxide

2.2 Label elements:

Eye irritation, category 2A.
Skin irritation, category 2.

Hazard pictograms:

Signal word: Warning

Hazard statements:
H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P332+P313 If skin irritation occurs: Get medical advice/attention.
P501 Dispose of contents and container as instructed in Section 13.

Additional information: None.

Hazard description

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

Hazards Not Otherwise Classified (HNOC): None

Information concerning particular hazards for humans and environment:

The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:

The classification is according to EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments, and extended by company and literature data. The classification is in accordance with the latest editions of international substances lists, and is supplemented by information from technical literature and by information provided by the company.

3 Composition/information on ingredients

3.1 Chemical characterization : None

3.2 Description : None

3.3 Hazardous components (percentages by weight)

Identification	Chemical Name	Classification	Wt. %
CAS number: 68081-81-2	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	10-25
CAS number: 1300-72-7	Sodium Xylenesulphonate	Eye Irrit. 2; H319	2.5-10
CAS number: 84133-50-6	Alcohol Ethoxylate	Skin Irrit. 2 ; H315 Eye Dam. 1; H318	2.5-10
CAS number: 1643-20-5	Lauramine oxide	Skin Irrit. 2 ; H315 Eye Dam. 1; H318	1-2

3.4 Additional Information: None.

4 First aid measures

4.1 Description of first aid measures

General information: None.

After inhalation:

Maintain an unobstructed airway.
Loosen clothing as necessary and position individual in a comfortable position.

After skin contact:

Wash affected area with soap and water.
Seek medical attention if symptoms develop or persist.

After eye contact:

Rinse/flush exposed eye(s) gently using water for 15-20 minutes.

Remove contact lens(es) if able to do so during rinsing.
Seek medical attention if irritation persists or if concerned.

After swallowing:

Rinse mouth thoroughly.
Seek medical attention if irritation, discomfort, or vomiting persists.

4.2 Most important symptoms and effects, both acute and delayed

None

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information.

5 Firefighting measures

5.1 Extinguishing media

Suitable extinguishing agents:

Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition.

For safety reasons unsuitable extinguishing agents : None

5.2 Special hazards arising from the substance or mixture :

Thermal decomposition can lead to release of irritating gases and vapors.

5.3 Advice for firefighters

Protective equipment:

Wear protective eye wear, gloves and clothing.
Refer to Section 8.

5.4 Additional information :

Avoid inhaling gases, fumes, dust, mist, vapor and aerosols.
Avoid contact with skin, eyes and clothing.

6 Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures :

Ensure adequate ventilation.
Ensure air handling systems are operational.

6.2 Environmental precautions :

Should not be released into the environment.
Prevent from reaching drains, sewer or waterway.

6.3 Methods and material for containment and cleaning up :

Wear protective eye wear, gloves and clothing.

6.4 Reference to other sections : None

7 Handling and storage

7.1 Precautions for safe handling :

Avoid breathing mist or vapor.
Do not eat, drink, smoke or use personal products when handling chemical substances.
Conditions for safe storage, including any incompatibilities:
Store closed upright and in a cool dry place, should be 15 - 30 deg C or 60 - 90 deg F.

7.2 Specific end use(s):

No additional information.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

8 Exposure controls/personal protection

8.1 Control parameters :

No applicable occupational exposure limits

8.2 Exposure controls

Appropriate engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use or handling.

Respiratory protection:

Not needed under normal conditions.

Protection of skin:

Select glove material impermeable and resistant to the substance.

Eye protection:

Safety goggles or glasses, or appropriate eye protection.

General hygienic measures:

Wash hands before breaks and at the end of work.
Avoid contact with skin, eyes and clothing.

9 Physical and chemical properties

Appearance (physical state, color):	Pale yellow liquid	**Explosion limit lower**: **Explosion limit upper**:	Not determined or not available. Not determined or not available.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or not available.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or not available.
pH-value:	8.5 as is	**Relative density**:	Not determined or not available.
Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or not available.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or not available.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or not available.
Evaporation rate:	Not determined or not available.	**Decomposition temperature**:	Not determined or not available.
Flammability (solid, gaseous):	Not determined or not available.	**Viscosity**:	a. Kinematic: Not determined or not available. b. Dynamic: Not determined or not available.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox	
Density at 20°C:	Not determined or not available.

10 Stability and reactivity

10.1 Reactivity : None

10.2 Chemical stability : None

10.3 Possibility hazardous reactions : None

10.4 Conditions to avoid : None

10.5 Incompatible materials : None

10.6 Hazardous decomposition products : None

11 Toxicological information

11.1 Information on toxicological effects :

Acute Toxicity:

Oral:

: LD50 >5000 mg per kg Rat, Oral) - product .

Chronic Toxicity: No additional information.

Skin corrosion/irritation:

Alcohol Ethoxylate: May cause mild to moderate skin irritation.

Sodium Alkylbenzene Sulfonate: Causes skin irritation.

Lauramine oxide: Causes skin irritation.

Serious eye damage/irritation:

Sodium Alkylbenzene Sulfonate: Causes serious eye irritation.

Alcohol Ethoxylate: Causes moderate to severe eye irritation and conjunctivitis.

Sodium xylenesulphonate: Rabbit: irritating to eyes.

Lauramine oxide: Causes serious eye damage.

Respiratory or skin sensitization: No additional information.

Carcinogenicity: No additional information.

IARC (International Agency for Research on Cancer): None of the ingredients are listed.

NTP (National Toxicology Program): None of the ingredients are listed.

Germ cell mutagenicity: No additional information.

Reproductive toxicity: No additional information.

STOT-single and repeated exposure: No additional information.

Additional toxicological information: No additional information.

12 Ecological information

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.

Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.4 mg/l, 48 hours.
Sodium Alkylbenzene Sulfonate: Aquatic Plants, EC50 Algae 29 mg/l, 96 hours.
Lauramine oxide: Fish, LC0 24.3 mg/l, 96h [Killifish (Cyprinodontidae)]
Lauramine oxide: Aquatic invertebrates, (LC50): 3.6 mg/l 96 hours [Daphnia (Daphnia)].
Lauramine oxide: Aquatic plants, EC50 Algae 0.31 mg/l 72 hours [Algae]
Alcohol Ethoxylate: Aquatic invertebrates, (LC50): 4.01 mg/l 48 hours [Daphnia (daphnia)].

12.2 Persistence and degradability: No additional information.

12.3 Bioaccumulative potential: No additional information.

12.4 Mobility in soil: No additional information.

General notes: No additional information.

12.5 Results of PBT and vPvB assessment:

PBT: No additional information.

vPvB: No additional information.

12.6 Other adverse effects: No additional information.

13 Disposal considerations

13.1 Waste treatment methods (consult local, regional and national authorities for proper disposal)

Relevant Information:

It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities. (US 40CFR262.11).

14 Transport information

14.1 UN Number: ADR, ADN, DOT, IMDG, IATA	None
14.2 UN Proper shipping name: ADR, ADN, DOT, IMDG, IATA	None
14.3 Transport hazard classes: ADR, ADN, DOT, IMDG, IATA	**Class:** None **Label:** None **LTD.QTY:** None

US DOT
Limited Quantity Exception: None

Bulk:	Non Bulk:
RQ (if applicable): None	**RQ (if applicable):** None
Proper shipping Name: None	**Proper shipping Name:** None
Hazard Class: None	**Hazard Class:** None
Packing Group: None	**Packing Group:** None
Marine Pollutant (if applicable): No additional information.	**Marine Pollutant (if applicable):** No additional information.
Comments: None	**Comments:** None

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

14.4 Packing group: ADR, ADN, DOT, IMDG, IATA	None
14.5 Environmental hazards :	None
14.6 Special precautions for user:	None
Danger code (Kemler):	None
EMS number:	None
Segregation groups:	None

14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code: Not applicable.

14.8 Transport/Additional information:

Transport category:	None
Tunnel restriction code:	None
UN "Model Regulation":	None

15 Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture.

North American

SARA

Section 313 (specific toxic chemical listings): None of the ingredients are listed.
Section 302 (extremely hazardous substances): None of the ingredients are listed.

CERCLA (Comprehensive Environmental Response, Clean up and Liability Act) Reportable Spill Quantity: None of the ingredients are listed.

TSCA (Toxic Substances Control Act):

Inventory: All ingredients are listed.
Rules and Orders: Not applicable.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredients are listed.

Chemicals known to cause developmental toxicity: None of the ingredients are listed.

Canadian

Canadian Domestic Substances List (DSL):
All ingredients are listed.

EU

REACH Article 57 (SVHC): None of the ingredients are listed.

Germany MAK: Not classified.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

Asia Pacific

Australia

Australian Inventory of Chemical Substances (AICS): All ingredients are listed.

China

Inventory of Existing Chemical Substances in China (IECSC): All ingredients are listed.

Japan

Inventory of Existing and New Chemical Substances (ENCS): All ingredients are listed.

Korea

Existing Chemicals List (ECL): All ingredients are listed.

New Zealand

New Zealand Inventory of Chemicals (NZOIC): All ingredients are listed.

Philippines

Philippine Inventory of Chemicals and Chemical Substances (PICCS): All ingredients are listed.

Taiwan

Taiwan Chemical Substance Inventory (TSCI): All ingredients are listed.

16 Other information

Abbreviations and Acronyms: None

Summary of Phrases

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P332+P313 If skin irritation occurs: Get medical advice/attention.
P501 Dispose of contents and container as instructed in Section 13.

Manufacturer Statement:

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling,

use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

NFPA: 1-0-0

HMIS: 1-0-0

Appendix B
Glove Selection Guideline

APPENDIX B: GLOVE SELECTION GUIDELINE

HAZARD	EXAMPLE TASKS	ANSI CUT/ABRASION RATING*	REPRESENTATIVE GLOVE
Impact Hazards, Med/Heavy Duty Puncture Cut	Drilling/direct push activities. Construction. Heavy materials handling. Power tools. Air knifing. Excavation.	ANSI Cut and Abrasion Resistance **Level 5** **EN 388 4521**	Hexarmor®Chrome Hexarmor® GGT5 Hexarmor® L5 Hexarmor® SteelLeather III Ironclad® Kong Glove
Med/Heavy Duty Puncture Cut Oil/Solvent Resistant	Tasks where materials are treated with oil or solvents.	ANSI Cut and Abrasion Resistance **Level 3 - 4** **EN 388 4522**	Ansell Alpha-Tec ® Memphis® Ultra Tech Nitrile Cut & Splash Best® Neoprene 6780 Hexarmor™ TenX Threesixty
Medium Duty Cut/Puncture Gloves with Oily Surface Grip	Light materials handling, wet service	ANSI Cut and Abrasion Resistance **Level 3** **EN 388 44xx**	Best®Zorb-It Ultimate HV 4567 Ansell® Cut Protective Glove 97-505 Ansell HyFlex® 11-511 Ansell HyFlex® 11-624
Med/Heavy Duty Cut/Puncture	Light Materials Handling. System O&M. Use of Hand Tools. Hand Augering. Heavy Equipment Operator.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 33xx**	Perfect Fit® PF570 Hexarmor® Level Six 9010/9012 Ironclad® Cut Resistant Glove Ansell HyFlex® 11-511 Ansell HyFlex® 11-624 Ansell® Cut Protective Glove 97-505
Light Duty Cut/Puncture Abrasion Only	Handling soil and Groundwater Samples. Opening spoons. Well construction.	ANSI Cut and Abrasion Resistance **Level 2 - 4** **EN 388 21xx**	Memphis® Ninja Max N9676GL Memphis® UltraTech Dyneema 9676 Memphis® Ninja Ice (Cold Weather) Ansell HyFlex® 11-511 Ansell® Cut Protective Glove 97-505 Ansell® Powerflex 80-813 Ironclad™ Workforce
Light Duty Glove Cut/Abrasion (used under nitrile gloves)	Groundwater Sampling.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 21xx**	Ansell HyFlex® 11-500 Ansell HyFlex® 11-624 Ansell GoldKnit

* Reference to ANSI and EN 388 glove testing standards. Listed gloves meet the standards in the table, but are not the only gloves that meet the standard.

This selection chart is not intended to address all chemical hazards. Gloves used for chemical protection shall provide cut/puncture resistance, or be used in tandem with cut/puncture protection. Nitrile gloves used for environmental sampling must be used in tandem with a cut/puncture resistant glove.

Gloves available in high visibility colors have shown to be effective and are preferred.

Appendix C
Excavation Hazard Recognition Guide (Trenching/Shoring), Site Assessment Questions, and Related Guidance

1. PURPOSE

TRC's Trench and Excavation Compliance Program has been developed based on the Occupational Safety and Health Administration (OSHA) standards for the construction industry (29 CFR 1926, Subpart P – Excavations).

2. SCOPE

This Compliance Program applies to all open excavations made in the earth's surface. Excavations are defined to include trenches. These guidelines apply to all Operating Unit facilities and project sites.

3. DEFINITIONS

Accepted engineering practices: Those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring: A pre-engineered shoring system comprised of aluminum hydraulic cylinders (cross braces) used in conjunction with vertical rails (uprights) or horizontal rails (wales). Such system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole: A type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system): A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in: The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person: One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces: The horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation: Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or Sides: The vertical or inclined earth surfaces formed as a result of excavation work.

Failure: The breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere: An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kick-out: The accidental release or failure of a cross brace.

Protective system: A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp: An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer: A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting: The members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system): A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system): A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation, and which is designed to prevent cave-ins.

Sloping (Sloping system): A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock: Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp: A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system: A structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data: Tables and charts approved by a registered professional engineer, and used to design and construct a protective system.

Trench (Trench excavation): A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box: See Shield.

Trench shield: See Shield.

Type A soil: Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of cohesive soils are clay, silty clay, sandy clay, clay loam, and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hard pan are also considered Type A. However, no soil is Type A if:

- The soil is fissured.
- The soil is subject to vibration from heavy traffic, pile driving, or similar effects.
- The soil has been previously disturbed.
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater.
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B soil**:** Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; granular cohesion less soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and in some cases, silty clay loam and sandy clay loam; previously disturbed soils except those that would otherwise be classed as Type C soil; soil that meets the unconfined compressive strength or cementation requirements for Type A but is fissured or subject to vibration; dry rock that is not stable; material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C soil: Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; granular soils, including gravel, sand, and loamy sand; submerged soils, including soil from which water is freely seeping; submerged rock that is not stable; material in a sloped, layered system where the layers dip into the excavation at a slope of four horizontal to one vertical (4H:1V) or steeper.

Uprights**:** The vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales: Horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

4. RESPONSIBILITIES

4.1 TRC's National Safety Director is responsible for establishing the Trench and Excavation Program requirements and providing/communicating them to the Health and Safety Network. The National Safety Director will review contract documents as required that include project and Client-Specific Requirements.

4.2 The Health and Safety Network is responsible for the Trench and Excavation Program implementation including, but not limited to:

- Qualifying or identifying Competent Person(s) for trench and excavation safety.
- Training new and existing TRC employees.
- Communicating and coordinating TRC's Trench and Excavation Program requirements with all TRC subcontractors, including identification of Subcontractor(s) Competent Person(s).
- Procuring TRC health and safety equipment (harnesses, lanyards, vertical and horizontal lifeline and other materials).
- Working in conjunction with identified Competent Person(s) to provide on-site direction on Trench and Excavation issues.
- Leading all investigations along with the Competent Person, Project Manager, Field Team Leader, and subcontractor health and safety representative or their designees, if a Trench and Excavation Program violation occurs on-site.
- Assisting in Trench and Excavation Program audits in conjunction with on-site TRC subcontractor, and the health and safety representatives or their designees.
- Maintaining records for health and safety activities on-site including equipment inspections and procedural audits of employee Trench and Excavation Program implementation.
- Coordinating assistance during emergency situations.

4.3 OSHA defines a Competent Person as one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, who has authorization to take prompt corrective measures to eliminate them (29 CFR 1926.32[f]). By way of training and/or experience, a Competent Person is knowledgeable of applicable standards, and is capable of identifying workplace hazards related to the specific operation. Under TRC's Trench and Excavation Program the Competent Person will:

- Perform all duties as specified in the Trench and Excavation Program.

- Review and approve all Health and Safety Plans (HASPs) and Job Safety Analyses (JSAs) that include work in and around trenches and excavations.
- In the event of simultaneous operations, cooperate fully with the Subcontractor's Person in Charge.
- Communicate with performing authorities (i.e., employees working in or around trenches or excavations) regarding the presence of other operations on-site.
- Work with Project Manager and/or Field Team Leader to identify and manage the risks associated with the project site.
- Assist in the training of employees who will be performing tasks in and around a trench or excavation.
- Ensure that a rescue plan is established by working with the Project Manager and/or facility safety personnel prior to any employees entering or working around a trench or excavation.
- Provide guidance as required for Trench and Excavation Program issues and questions.
- Coordinate with Project Managers and Health and Safety Network on trench and excavation audits.
- Observe the implementation of Trench and Excavation Program and conduct audits as required or directed.

4.4 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the Trench and Excavation Program. Project Managers must hold all TRC and other project employees working on-site accountable (zero tolerance policy) for maintaining a safe work environment.

4.5 Project Managers and site employees shall be held accountable for performing work in a safe manner according to the requirements of the Trench and Excavation Program.

4.5.1 The Field Team Leader shall:

- Participate in Trench and Excavation Awareness training.
- Confirm that Competent Personnel prepared and/or reviewed the Site-Specific Rescue Plan if required.
- When required, confirm that everyone working under a specific permit adheres to the permit's documented conditions.

5. PROCEDURE

5.1 General Requirements Permit labor

The following guidelines establish the minimum requirements of the applicable state and federal safety regulations for all work in excavations and trenches that might expose employees to the hazards of moving ground:

- All surface encumbrances adjacent to an excavation that might create a hazard to employees must be removed, secured, or supported as necessary to protect employees.
- The estimated location of underground installations, such as sewer, telephone, electric, water, or other underground utilities must be identified before opening an excavation. Utility companies, owners, and local One Call locator services must be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations before the work begins.
- When excavations approach the estimated location of underground installations, the exact location is determined by probing or hand digging, as necessary, to prevent accidental contact with the underground installations. While the excavation is open, underground installations that create a hazard to employees will be supported, protected, or removed as necessary to protect employees.

5.1.1 Access and Egress - Structural ramps.

- Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.
- Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.
- Structural members used for ramps and runways shall be of uniform thickness.
- Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.
- Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments o the top surface to prevent slipping.
- Appropriate access and egress in the form of a stairway, ladder, or ramp must be provided in all excavations deeper than 4 feet (1.23 m). In trenches, the stairway, ladder, or ramp must be installed so that a worker does not have to travel farther than 25 feet (7.62 m) in any direction to exit.

- Employees exposed to vehicular traffic must wear safety vests or other equivalent apparel marked with or made of reflectorized or high-visibility material.
- No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.
- A warning system must be provided when mobile equipment is operated adjacent to an excavation and the operator does not have a clear and direct view of the edge of the excavation. The warning system may include barricades, signals, stop logs, or other authorized methods. If possible, the grade should be away from the excavation.
- When deemed necessary by a competent person, excavations where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.
- When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.
- Emergency rescue equipment, such as rescue breathing apparatus, a safety harness and line, or a basket stretcher must be available where a hazardous atmosphere exists or could be expected to develop in an excavation.
- Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.
- Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

- If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.
- Inspection of an excavation shall be made by a competent person when accumulation of water is present.
- If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person.
- The stability of adjacent structures, such as buildings, walls, and sidewalks must be maintained using a support system as necessary to protect employees.
- Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:
    - A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
    - The excavation is in stable rock; or
    - A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or
    - A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.
- Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.
- Employees must be protected from loose rock or soil that could fall or roll into the excavation by placing and keeping such material at least 2 feet (0.61 m) from the edge of the excavation.
- A competent person must make daily inspections of excavations to identify and eliminate conditions that could result in cave-ins, failure of support systems, hazardous atmospheres, or other unsafe conditions. Inspections must be conducted before the start of work each day and after every rainstorm or other occurrence that might increase the hazard of moving ground. If problems are found, provisions should be made for immediate removal of personnel.

- Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.
- Where employees or equipment are allowed or required to cross over excavations that are 6 feet
- (1.83 m) or greater in depth, appropriate fall protection in the form of walkways or bridges with standard guardrails must be provided.
- An open excavation or trench that is left open overnight must be barricaded, covered, and secured in a manner that prevents anyone from entering the excavation intentionally or accidentally.

5.2 Protective Systems

Sloping, shoring, or shielding will be provided in excavations, except where the excavation is made in stable rock or the excavation is less than 5 feet (1.52 m) deep and an examination by a competent person does not indicate a potential for cave-in.

5.3 Sloping

When sloping or benching is chosen as the method to protect employees in an excavation, one of the following optional designs of sloping and benching systems must be used:

- Option 1 – Slope the excavation at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal).
- Option 2 – Perform a soil classification and determine the acceptable slopes required.
- Option 3 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and must include the name and registration number of the engineer, detailed plans, the calculations used in the design, the magnitude of slopes, and the configurations determined to be safe. A copy of the design will be maintained at the jobsite during the use of the engineered system.

5.4 Shoring or Shielding

Only the following methods for support systems, shield systems, and other protective systems can be used at a TRC jobsite:

- Option 1 – Perform a soil classification and determine the appropriate support, shield or other protective system configuration using the shoring manufacturer’s tabulated data.

When using the manufacturer's tabulated data, the shoring system must be installed in accordance with all the specifications, recommendations, limitations, or approvals to deviate issued by the manufacturer. The manufacturer's tabulated data, specifications, recommendations, limitations, and any approval to deviate must be in writing, and maintained at the jobsite during the use of the shoring system.

- Option 2 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and include the name and registration number of the engineer, detailed plans, the calculations used in the design, and the sizes, types, and configurations of materials to be used in the support system. A copy of the design must be maintained at the jobsite during the use of the engineered system.

5.5 General Guidelines

The materials and equipment used for protective systems must be free of damage or defects that might impair their proper functions. Manufactured materials and equipment must be used and maintained in accordance with the recommendations of the manufacturer. If material or equipment used in a protective system is damaged, it must be inspected by a competent person before being reused.

The installation and removal of protective systems must be performed in accordance with all of the following guidelines:

- Members of support systems must be securely fastened together to prevent sliding, falling, kick-outs, or other predictable failures.
- Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or being struck by members of the support system.
- Individual members of support systems must not exceed their design capacities.
- Before individual members can be removed, additional precautions must be taken to protect employees, including installing other structural members to support any additional load imposed on the support system.
- Removal begins at, and progresses from, the bottom of the excavation. Members must be released slowly to reduce the likelihood of failure of the remaining members or a cave-in.
- Backfilling must progress with the removal of support systems.
- Support systems must be coordinated with the excavation of trenches and must extend to within 2 feet (0.61 m) of the bottom of the trench, but only if the system is designed to resist the forces calculated for the full depth of trench, and there is no indication of a loss of soil from behind or below the bottom of the support system.

- Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.
- Shield systems must not be subjected to loads exceeding their design capacities. Shields must be installed in a manner that restricts lateral or hazardous movement in the event that a lateral load is applied suddenly. Employees must be protected when entering or exiting the areas protected by a shield. Employees are not allowed within the shield during installation, removal, or vertical movement.
- When shield systems are used in trenches, excavation of material may proceed 2 feet (0.61 m) below the bottom of the shield only if the shield is designed to resist the forces calculated for the full depth of trench and there is no indication of a loss of soil from behind or below the bottom of the shield.

5.6 Soil Classification

This section describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits.

- Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C, in accordance with the definitions set forth in this compliance program.
- Soil and rock deposits are classified based on the results of at least one visual and one manual analysis. These analyses must be conducted by a competent person using the tests described in this chapter or other approved methods of soil classification, such as those adopted by the American Society for Testing Materials (ASTM) or the United States Department of Agriculture (USDA).
- The methods used for visual and manual analyses must provide quantitative and qualitative information sufficient to identify the properties, factors, and conditions of the deposits.
- A layered system must be classified based on the weakest layer. However, each layer may be classified individually when a more stable layer lies below a less stable layer.
- If, after classifying a deposit, the properties, factors, or conditions change in any way, the changes must be evaluated by a competent person. The deposit must be reclassified as necessary to reflect the new circumstances.

5.7 Visual Analysis

The visual analysis is conducted to collect qualitative information about the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the excavation, and soil samples taken from the excavated material. The visual analysis includes:

- Observing samples of the soil that are excavated and soil in the sides of the excavation to estimate the range of particle sizes and the relative amounts of particle sizes. Fine-grained material is cohesive.
- Observing the soil as it is excavated to determine if it stays in clumps. Soil that breaks up easily and does not stay in clumps is granular.
- Observing sides of the opened excavation and the surface area adjacent to the excavation to identify tension cracks or fissured material.
- Observing the area adjacent to the excavation and the excavation itself to identify existing underground utilities, structures, or previously disturbed soils.
- Observing the opened sides of the excavation to identify layered systems. Examine layered systems to determine if the layers slope toward the excavation, and to estimate the degree of slope in the layers.
- Observing the area adjacent to the excavation and the areas within the excavation to identify potential sources of vibration that might affect the stability of the excavation.
- Observing the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the water table.

5.8 Manual Analysis

Manual analysis is conducted to collect quantitative and qualitative information about the properties of the soil, and to provide more information to properly classify the soil. The manual analysis includes some or all of the following methods:

- Evaluating the plasticity of the soil by molding a moist or wet sample of soil into a ball and attempting to roll it into threads as thin as 1/8 inch (0.32 cm) in diameter. Cohesive material can be rolled into a thread at least 2 inches (5.08 cm) long without crumbling or breaking.
- Evaluating the cohesiveness of the soil. If the soil is dry and crumbles into individual grains or fine powder with little or moderate pressure, it is granular. If the soil is dry and falls into clumps that break into smaller clumps but the smaller clumps can only be broken up with difficulty, it might be clay in combination with gravel, sand, or silt. If the dry soil breaks into small clumps that can only be broken with difficulty and there is no visual indication the soil is fissured, the soil may be considered unfissured.

- Applying the thumb penetration test to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb and can be molded by light finger pressure.
- The thumb test should be conducted on an undisturbed soil sample, such as a large clump of soil, as soon as possible after excavation to minimize the effects of drying. If the excavation is later exposed to rain, flooding, or other moisture, the classification of the soil must be changed accordingly.
- Estimating the unconfined compressive strength of soils by using a pocket penetrometer or a hand-operated shear vane in accordance with the manufacturer's recommendations.
- Performing a drying test to differentiate among cohesive material with fissures, unfissured cohesive material, and granular material. After thoroughly drying a sample of soil that is approximately 1 inch (2.54 cm) thick and 6 inches (15.24 cm) in diameter, evaluate the results as follows:
  - If the sample develops cracks as it dries, significant fissures are indicated.
  - If the sample dries without cracking and can be broken by hand, then the material is either unfissured cohesive or fissured cohesive.
  - If considerable force is necessary to break the sample, the soil has significant cohesive material content. The soil can be classified as unfissured cohesive material, and the unconfined compressive strength should be determined.
  - If the sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

5.9 Sloping and Benching Specifications

This section contains the specifications for using sloping and benching to protect employees working in excavations.

- These slope and bench specifications only apply if a soil classification has been conducted and the excavation will be 20 feet (6.10 m) deep or less.
- Determine the maximum allowable slope and configuration based on the soil classification by using the information in table(s) 1, 2 and 3.

Table 1 Maximum Allowable Slope Based on Soil Classification

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)[1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP[3]
STABLE ROCK	VERTICAL (90º)
TYPE A[2]	3/4:1 (53º)
TYPE B	1:1 (45º)
TYPE C	1½:1 (34º)

1. The numbers shown in parentheses next to the maximum allowable slopes are angles expressed in degrees from the horizontal. The angles have been rounded off.
2. A short-term, maximum slope of 1/2:1 (63 degrees) is allowable in excavations in Type A soil less than 12 feet (3.66 m) deep. The short-term maximum allowable slopes for excavations deeper than 12 feet (3.66 m) is 3/4 (53 degrees).
3. Sloping or benching for excavations deeper than 20 feet (6.10 m) must be designed by a registered professional engineer.

Table 2 Excavations in Type A, B, and C Soils

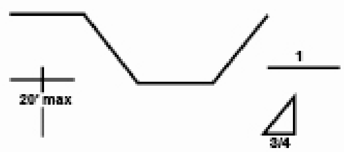
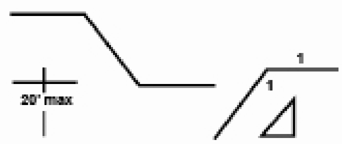
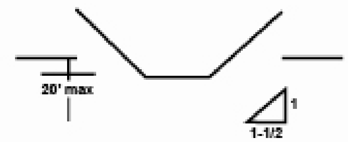
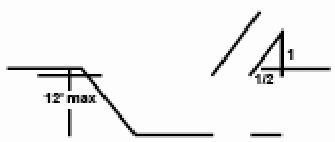
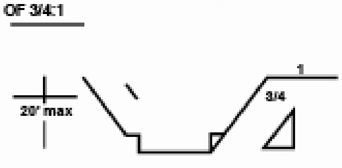
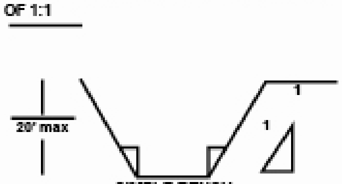
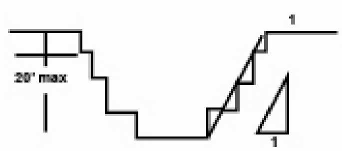
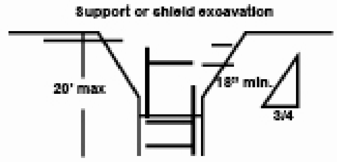
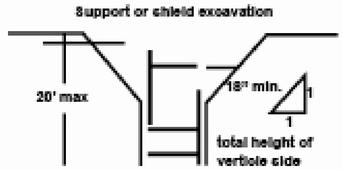
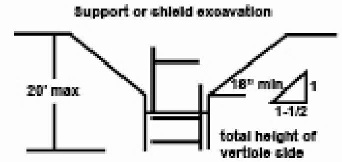
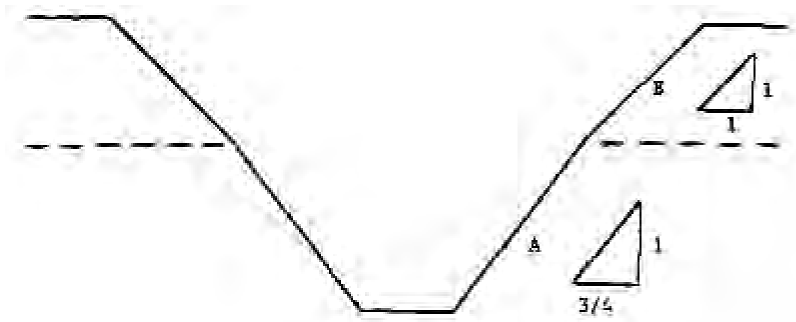
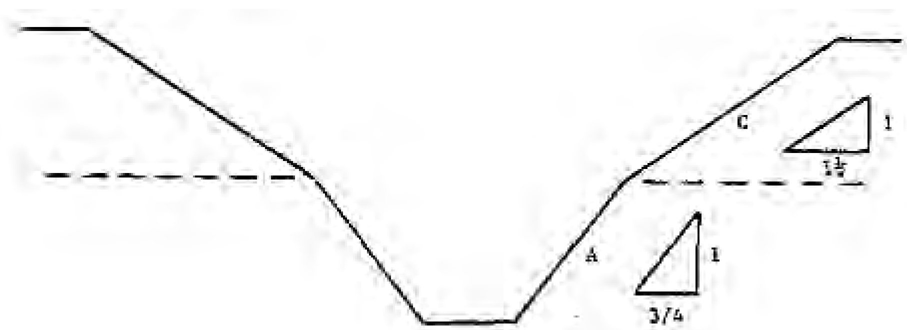
EXCAVATIONS IN TYPE A SOIL	EXCAVATIONS IN TYPE B SOIL	EXCAVATIONS IN TYPE C SOIL
SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1  SIMPLE SLOPE
EXCEPTION: SHORT-TERM SIMPLE SLOPES LESS THAN 12 FEET DEEP HAVE A MAXIMUM SLOPE OF 1/2:1  SIMPLE SLOPE SHORT-TERM		
BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE BENCH	BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
 MULTIPLE BENCH	 MULTIPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1. Support or shield excavation  SUPPORTED LOWER PORTION
THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.

Table 3 Excavations Made in Layered Soils

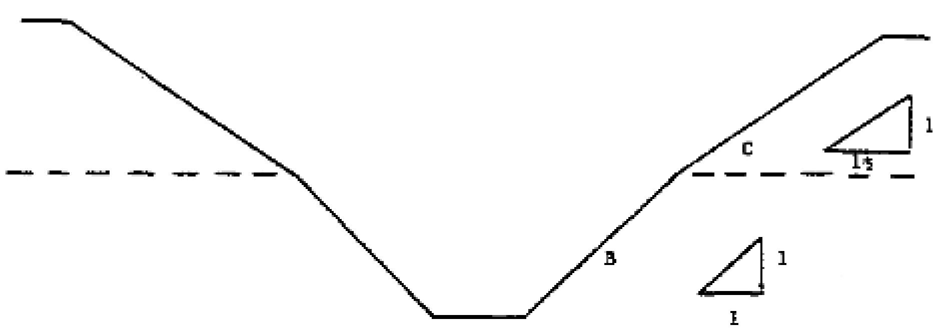
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



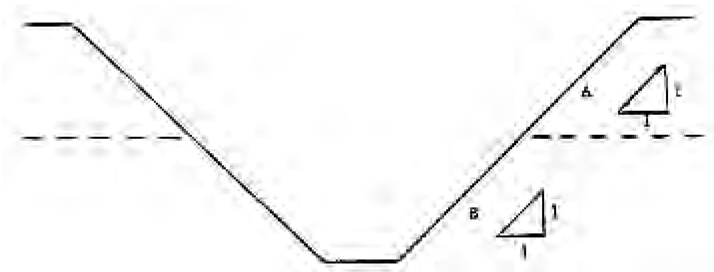
B OVER A



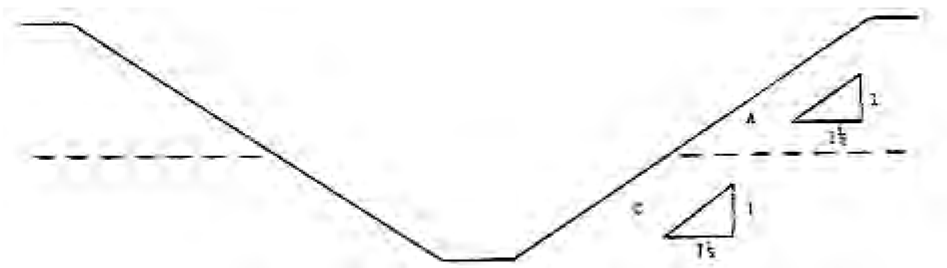
C OVER A



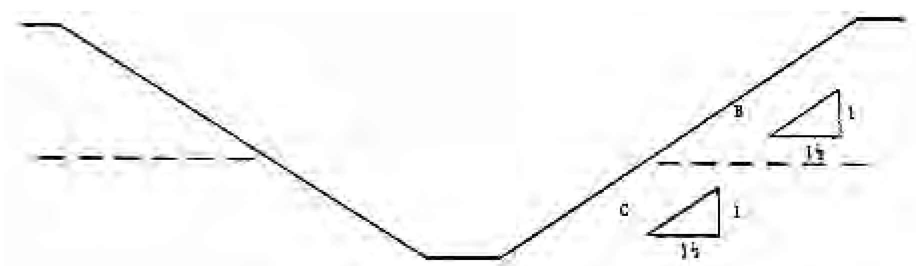
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

6. REFERENCES / RELATED DOCUMENTS:

29 CFR 1926 Subpart P, Excavations

CP002 – Risk Analysis Site Specific Health and Safety Program

CP003 – Personal Protective Equipment Program

CP008 – Confined Space Entry Program

CP009 – Health and Safety Training Program

7. APPENDICES

Forms

A. TRC Site-Specific Excavation Plan
B. TRC Pre-Excavation Checklist
C. TRC Excavation Inspection Form
D. TRC Protective Systems Selection Flow Chart

FORMS

A. **TRC SITE-SPECIFIC EXCAVATION PLAN**
B. **TRC PRE-EXCAVATION CHECKLIST**
C. **TRC EXCAVATION INSPECTION FORM**
D. **TRC PROTECTIVE SYSTEMS SELECTION FLOW CHART**

Site Specific Excavation Plan

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

Surface Encumbrances

Have Surface encumbrances that may create a hazard been removed or supported?

☐ Yes

☐ N/A

Underground Installations

Have Utility companies or owners been contacted? ☐ Yes ☐ N/A

By whom: Work Order #: Date:

When excavation operations approach the estimated location of underground installations, how will the exact location of the installations shall be determined?

☐ Probing ☐ Hand digging ☐ Detecting equipment ☐ Other

How will underground installations be protected?

☐ Support ☐ Removal ☐ Other

Access and Egress

Will structural ramps be used? ☐ Yes ☐ N/A

Designed by a competent person? ☐ Yes ☐ N/A

Will excavations be 4 feet in depth or more? ☐ Yes ☐ N/A

Means of egress (requiring no more than 25 feet of lateral travel) ☐ Yes ☐ N/A

☐ Stairway(s) ☐ Ramp(s) ☐ Ladder(s) ☐ Other

Exposure to vehicular Traffic? ☐ Yes ☐ N/A (If yes workers shall wear warning vests or other suitable garments.)

Exposure to falling loads? ☐ Yes ☐ N/A

☐ No workers permitted underneath loads

☐ Workers shall be required to stand away from any vehicle being loaded or unloaded. (Operators may remain in cabs)

Warning System for Mobile Equipment

Will mobile equipment operated adjacent to, or approaching the edge of, excavations have a clear and direct view of the edge of the excavation?

☐ Yes ☐ N/A If yes what warning system will be utilized?

☐ Barricade(s) ☐ Hand Signals ☐ Stop logs ☐ Other

Hazardous Atmospheres

Can oxygen deficiency or a hazardous atmosphere reasonably be expected to exist? ☐ Yes ☐ N/A

If yes, how will atmospheres in excavations greater than 4 feet in depth be tested?

If atmospheres contain less than 19.5% oxygen or other hazardous substance how will it be remediated?

When controls are intended to reduce the level of contaminants to acceptable levels, testing shall be conducted:

☐ Continuously ☐ Periodically

Will emergency rescue equipment be utilized? ☐ Yes ☐ N/A If yes what type?

☐ SCBA ☐ Harness and line ☐ Basket stretcher ☐ Other

Site Specific Excavation Plan

Water Accumulation

Will workers work in excavations in which there is accumulated water? ☐ Yes ☐ N/A

If yes is water controlled or prevented from accumulating by water removal equipment? ☐ Yes ☐ N/A

Equipment type: Competent Person:

Does excavation work interrupt the natural drainage of surface water (such as streams)? ☐ Yes ☐ N/A

Method used to divert water:

Stability of Adjacent Structures

Will the stability of adjacent structures be endangered by excavation operations? ☐ Yes ☐ N/A

If yes, what type of support structure will be used?

☐ Shoring ☐ Bracing ☐ Underpinning ☐ Other

If yes, but support structures will not be used, one of the following must apply:

☐ The excavation is in stable rock

☐ A registered professional engineer has determined that such work will not pose a hazard.

Name of registered professional engineer:

Protection from Loose Rock or Soil

How will workers be protected from materials or equipment that could fall or roll into excavations?

☐ Material placed > 2 feet from edge Retaining devices

Inspections

☐ Inspections of all excavations, adjacent areas and protective systems shall be made by a competent person.

☐ Inspections shall be conducted by the competent person daily, prior to the start of work and as needed throughout the shift. Inspections shall be documented on a Daily Excavation Inspection Form.

☐ Inspections shall be made after every rainfall or other hazard increasing occurrence.

☐ Where the competent person finds evidence of hazardous conditions, workers shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

Fall Protection

Will excavations be 6 feet or greater in depth? ☐ Yes ☐ N/A

If yes, fall protection will consist of:

☐ Barricades ☐ Fall restraint ☐ Harness ☐ Other

Will workers be required or permitted to cross over excavations? ☐ Yes ☐ N/A

If yes, guardrails shall be provided.

SIGNATURES

Supervisor General Supervisor

Project/Construction Manager Safety Representative

Pre-Excavation Checklist

Project Name: **Project #:**
Location: **Date:**
Company: **One Call #**
Submitted By:

The following procedures are mandatory. Failure to complete this check list could result in disciplinary action or termination:

Complete a pre-excavation walk-out of the entire job site. Your objective is to visually inspect the dig area to ensure all utilities are marked. Look for obvious signs of utilities in the immediate work area that may not be marked such as, above-ground pedestals, gas meters, man-hole covers, drains, or utility poles with cable risers. If you find these indicators and suspect that there is an unmarked utility DO NOT PROCEED**. Call your General Foreman or Locate Ticket Coordinator immediately.**

When you have completed your walk-out, complete the following check list:

1. Verify that the One-Call ticket covers the 'Scope of work' and 'Work to begin' date:

   I have verified the One-Call ticket covers the 'Scope of work' &'Work to begin' date ☐

2. What marked utilities did you observe?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

3. Based on visual observation, did you see any obvious signs of unmarked utilities in the immediate work area?

   ☐Yes ☐No If Yes, please identify?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

4. I have notified my Supervisor and Locate Ticket Coordinator ☐
5. Photograph the entire proposed work area including all locate marks.

   I have photographed the entire site including existing locate/markings prior to excavation ☐

6. Advise your crew members of the following: If they have to cross a marked Utility they must HAND DIG ONLY within 18" of the locate marks. For gas lines add half the diameter of the buried facility to the 18''. If necessary, dig a test-hole (pothole) using hand tools to determine the location of the facility.

   I have advised my crew of this rule ☐

7. When possible, all directional boring / drilling routes must be potholed every 50-80 feet prior to drilling.

   I have advised my crew accordingly and test-holes (potholes) have been dug ☐

~~~~~~~~~~~~~~~~~~~~~~~~~~~~ RESPECT THE MARKS! ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

IN THE EVENT OF DAMAGE

- Notify your Supervisor and Locate Ticket Coordinator
- Complete the TRC Incident Notification Form
- Photograph entire area and damage location

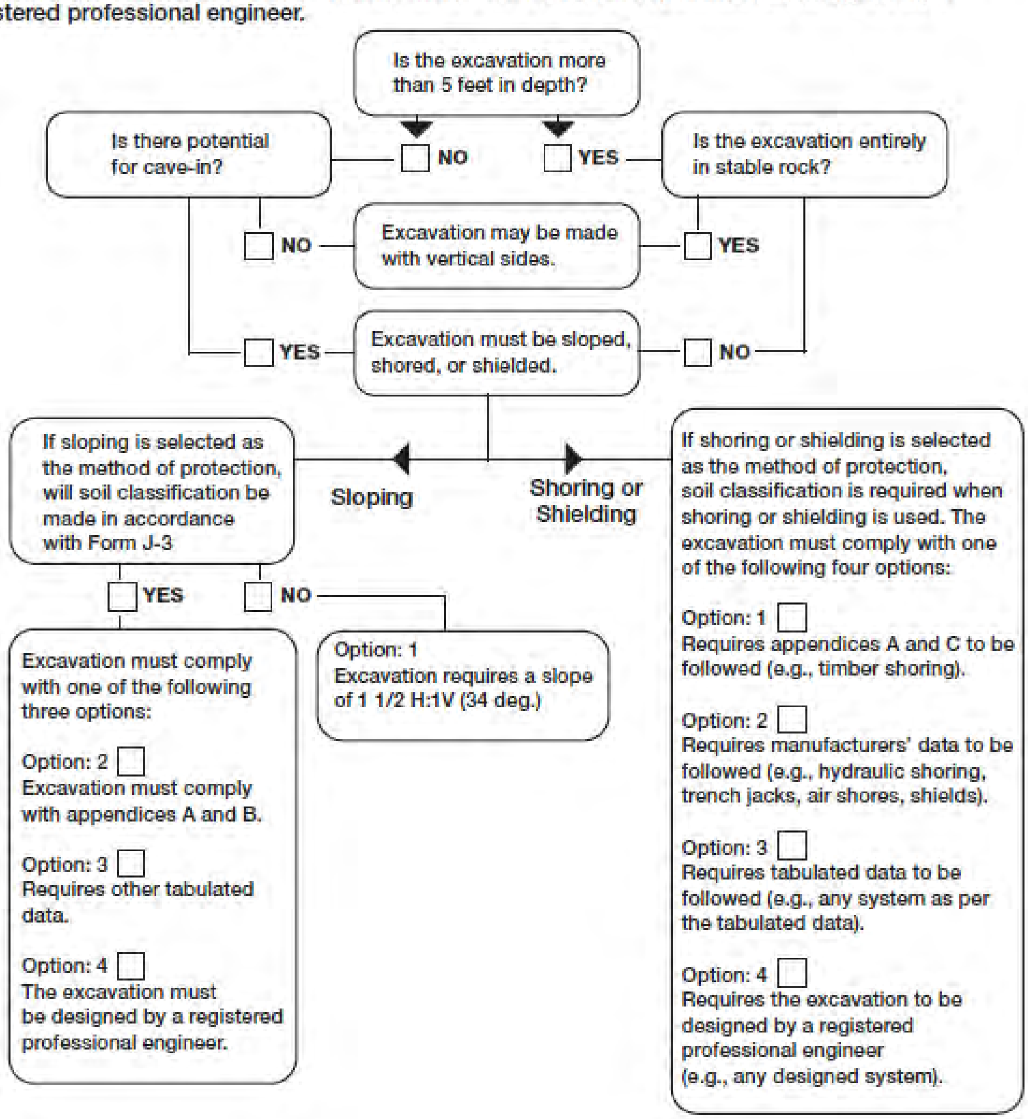
PHOTOGRAPHY TIPS

- Make sure the correct date & time stamp is active on your camera
- Photograph the excavation itself (damage location) and cable depth (include tape measure in hole)
- Take photos from multiple vantage points and of surrounding area (360 degrees)
- If the utility was miss-marked, photograph the locate marks/flags (include tape measure in photo)
- If the utility was not marked, photograph the entire area and approaches to the cut site
- Show a quantifiable location/address (street sign, house number, mail box number etc.)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Excavation Flow Diagram

Project Name:
Project #:
Location:
Date:
Company:
Submitted By:

The following is a graphic summary of the requirements for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer.



Excavation Daily Inspection

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

Depth: ________________________ **Width:** ________________________ **Date Opened:** ____________________

Soil classification: ☐ A ☐ B ☐ C

Indicate how the classification was made:

Manual test(s)

a) plasticity	________	________	________
b) dry strength	________	________	________
c) thumb penetration	________	________	________
d) pocket penetrometer	________	________	________
e) other	________	________	________

Visual test(s) **Do as many as possible**	**Cohesive Soil**	**Granular Soil**
a) Spoil pile	☐ **Remains in clumps**	☐ **Breaks up easily**
b) Trench Side	☐ **Stands vertical >2 hours**	☐ **Sloughs into trench**

The excavation is properly (circle one):

Shored/Shielded	**(indicate type of shoring)**	☐ **closed**	☐ **open**	☐ **wood**	☐ **metal**	☐ **shield**
Sloped/benched	**(indicate the slope)**	☐ **vertical sides**	☐ **3/4:1**	☐ **1:1**	☐ **1 1/2: 1**	☐ **2:1**

Excavation Checklist:	Morning	Mid-Day	Afternoon
Time:	________	________	________
Weather:	________	________	________
Was atmospheric testing required?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Was atmospheric testing done?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Is the spoil pile back 2' from the edge?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Have surface encumbrances been removed?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Are there any signs of sloughing or cave-in?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Is there water accumulation in the bottom?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Are there vibration sources near the excavation?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Is there adequate access/egress (ladder, ramp, etc.)	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Has the soil been disturbed previously?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Sides	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Top	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
If the excavation is > 20 feet deep, have engineering designs been documented and complied with?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no

SIGNATURES

Supervisor General Supervisor

Project/Construction Manager Safety Representative

Appendix D
Heat and Cold Stress

COLD STRESS

Ambient air temperatures during site activities may create cold stress for on-site workers. Procedures for recognizing and avoiding cold stress must be followed. Cold stress can range from frostbite to hypothermia. The signs and symptoms of cold stress are listed below.

Frostbite is defined as the actual freezing of one or more layers of skin. In severe cases, organs and structures below the skin can become frozen. Usually, body areas exposed to the most cold, and least body warmth, are affected first. These areas include fingers, toes, ears, and the tip of your nose. Frostbite is characterized by pain and loss of dexterity in the affected limb. The tissue initially appears reddened, but may progress to white, blue, or black.

> **FIRST AID:** Bring the affected employee indoors and call the local emergency clinic. Rewarming of frostbitten parts is best left to a medical doctor in a controlled setting.

Hypothermia is the condition that occurs when the body's natural warming mechanisms (muscle activity and shivering) cannot counteract the loss of body heat to the environment. The onset of hypothermia is greatly hastened by being wet. Hypothermia is marked by severe, uncontrollable shivering. The patient will show signs of excessive fatigue, drowsiness, irritability, or euphoria. As hypothermia progresses, the patient will begin to lose consciousness, blood pressure will drop, shivering will cease, and the patient may slip into a coma and possibly die.

> **FIRST AID:** If these symptoms occur, remove the patient to a warm, dry place. If clothing is wet, remove and replace with dry clothing. Keep the patient warm, but not overheated. The patient should be gradually rewarmed to prevent shock. If the patient is conscious and alert, warm liquids should be provided. Coffee and other caffeinated liquids should be avoided because of diuretic and circulatory effects. Notify the emergency clinic if conditions worsen, the patient loses consciousness, or the patient has an altered mental status. Have the patient transported to an emergency facility.

General Precautions The reduction of adverse health effects from cold exposure can be achieved by adopting the following work practices.

- Provide adequate insulating clothing to maintain core temperature at 98.6° F if work is to be performed in air temperatures below 40° F. Wind chill cooling rates and the cooling power of air are critical factors. The higher the wind speed and the lower the air temperature in the work area, the greater the insulation value of the protective clothing should be.
- If the air temperature is 32° F or less, hands should be protected by mittens/gloves.
- If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of clothing should be impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outer layer should be changed as it becomes wet. The outer garments should include provisions for easy ventilation in order to prevent wetting of the inner layer by sweat.
- If available clothing does not give adequate protection to prevent cold injury, work should be modified or suspended until adequate clothing is available, or until weather conditions improve.
- For prolonged work, heated shelters should be available. Workers should be encouraged to use these at regular intervals, with the frequency depending on the severity of the environmental exposure. When entering the shelter, the outer layer of clothing should be removed and the remainder of the clothing

loosened to permit heat evaporation, or a change of work clothing should be provided.

- Warm, sweet drinks, such as hot cocoa or soup, should be available at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of diuretic and circulatory effects.
- The weight and bulk of cold-weather gear should be included in estimating the required work performance and weights to be lifted in the field.

Workers should be instructed in safety and health procedures regarding cold work environments as part of the pre-work safety meeting. The training program should include instruction in preventing, recognizing, and treating cold stress conditions.

Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

HEAT STRESS

There is a potential for heat stress from the use of protective clothing and climate conditions. One or more of the following procedures may be employed to alleviate potential heat stress problems in the event that site conditions warrant the use of personal protective equipment (PPE), or ambient temperatures exceed 85° F. Heat stress training must be emphasized during the daily safety meetings, and adequate supplies of potable water must be provided to workers each day.

General Precautions Provide plenty of liquids. To replace body fluids (water and electrolytes) lost because of sweating, use a 0.1 percent saltwater solution, more heavily salted foods, or commercial drink mixes. The commercial mixes may be preferable for those employees on a low sodium diet. Employees on low sodium diets, or other special diets, are advised to contact their personal physician for recommendations regarding appropriate electrolyte replacement fluids/beverages.

In extremely hot weather, conduct operations in early morning or evening and rotate shifts of workers wearing impervious clothing. Install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

Ensure that adequate shelter is available for breaks to protect personnel against heat, which can decrease physical efficiency and increase the probability of accidents.

Acclimatization for workers not accustomed to working in elevated temperature environments will be considered and implemented as appropriate in accordance with American Conference of Governmental and Industrial Hygienists (ACGIH) Guidelines.

Heat Stress Monitoring

For monitoring the body's recuperative ability toward excess heat, one or more of the following techniques should be used as a screening mechanism. Monitoring of personnel wearing impervious clothing should commence when the ambient temperature is 70° F or above. Frequency of monitoring should increase as the ambient temperature increases or as slow recovery rates are indicated. When temperatures exceed 80° F, regardless of the use of Personal Protective Equipment (PPE), workers will be monitored for heat stress after every work period.

Good hygienic standards must be maintained by the employee to aid in the prevention of heat stress illnesses. At a minimum, frequent changes of clothing and daily showering should occur with clothing being allowed to dry during rest periods. Persons who notice skin problems should immediately inform their supervisor.

Heart rate (HR) should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 25 percent. The HR is then measured again, once each minute for 2 minutes (a total of three measurements), after the initial rest period measurement. The HR should decrease by ten beats per minute between each measurement (a total reduction of 20 beats). If the HR does not decrease, the work period should be reduced by an additional 25 percent.

Body temperature can be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99°F. If it is greater than 99°F, the next work period should be shortened by 25 percent. The OT should be measured again at the end of the rest period to make sure that it has dropped below 99° F.

Effects of Heat Street

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat loading, a number of physical reactions can occur. The severity of these reactions ranges from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to severe (fatal).

Heat-related illnesses include:

Heat rash (also known as prickly heat rash) is caused by continuous exposure to heat and humid air and aggravated by chafing clothes. Heat rash decreases the ability to tolerate heat as well as being a nuisance. Signs are not limited to, but may include, a red prickly rash.

> **FIRST AID:** Employees exhibiting signs of heat rash will be directed to shower and change into clean, dry clothing.

Heat cramps are caused by profuse perspiration with inadequate fluid intake and electrolyte replacement (especially salts). Signs are muscle spasms and pain in the extremities and abdomen, and may occur several hours after work has stopped.

> **FIRST AID:** Employees showing signs of heat cramps will be directed to lie in a cool, shady area, and drink cool fluids. If symptoms persist or worsen, the employee will be transported to an emergency facility.

Heat exhaustion is caused by increased stress on various organs to meet increased demands to cool the body. Signs are shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and lassitude.

> **FIRST AID:** Employees with signs of heat exhaustion will be brought to a cool, shady location and given fluids. After recovering, the employee will be dismissed for the day. If employee is unconscious, or conditions persist, the employee will be transported to a hospital.

Heat stroke is the most severe form of heat stress. The body must be cooled immediately to prevent severe injury and/or death. Signs and symptoms are red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and/or coma.

> **FIRST AID:** HEAT STROKE IS A MEDICAL EMERGENCY. Employees will be brought to a cool area, aggressively treated by removing constricting clothes and applying wet towels or ice packs, and transported without delay to an emergency facility.

Appendix E
Tailgate Meeting/Checklist

Daily Pre-Job Safety Briefing

Project Name: ______________________ Project Number: ______________

Work Location: ______________________ Date: ______________

Tasks Performed: ______________________ Time: __________ AM PM

Client Name: ______________ Submitted By: ______________

Weather: ______________________

Refuge Area: ______________________

First Aid/CPR Persons: ______________________

Potential Hazards: ______________________

For Emergencies Dial 911 **For Non-Emergencies Dial WorkCare (888) 449-7787**

Personal Protective Equipment Required

	Yes	*No*	*Specify*
Clothing	☐	☐	________
FR, reflective vest, chemical, other (specify)			
Eye/Face	☐	☐	________
Safety glasses, goggles, face shield, other (specify)			
Respirator	☐	☐	________
1/2 face, full face, other (specify)			
Foot Protection	☐	☐	________
Safety toe, EH rated, rubber boots, other (specify)			
Hand Protection	☐	☐	________
Kevlar, chemical, EH, other (specify)			
Head Protection	☐	☐	________
hard hat, electrical hazard, other (specify)			
Fall Protection	☐	☐	________
body harness, lifelines, barricades, other (specify)			
Hearing Protection	☐	☐	________

Other: ______________________

Procedures/Programs Required	*Yes*	*No*
Confined Space	☐	☐
Hot Work	☐	☐
Signs/Barricades	☐	☐
LOTO/Energy Control	☐	☐
Scaffolds/Aerial Lifts	☐	☐
________	☐	☐
________	☐	☐
________	☐	☐
________	☐	☐
Employee Certification/Training Required		
HAZWOPWER	☐	☐
Asbestos Awareness	☐	☐
Asbestos Inspector	☐	☐
XRF Trained	☐	☐
________	☐	☐
________	☐	☐
________	☐	☐

Additional Considerations

Work Procedures: ☐ Dig Safe
☐ Working clearances ☐ ________
☐ ________

People: ☐ Worker fatigue ☐ Other site activities
☐ Public safety ☐ Pedestrian control ☐ Experience
☐ Traffic control ☐ Other utilities
☐ ________

Tools/Equipment: ☐ Eye wash ☐ First Aid Kit
☐ Inspection of tools/equipment
☐ Specialized tools/equipment
☐ Correct tool/equipment for the job
☐ ________

Special Precautions: ☐ Environmental
☐ Condition of structures ☐ Weather conditions
☐ Lighting conditions ☐ Terrain ☐ Water bodies
☐ Adjacent structures
☐ ________

If Conditions CHANGE…Stop Work, Review and Revise the Plan!!

Daily Pre-Job Safety Briefing

Hazards Associated with the Job				
☐ Hazardous Chemicals	☐ Heavy Equipment	☐ Slip/Trip and Falls	☐ Work in Active Rail ROW	☐ Confined space
☐ Biological Waste	☐ Hostile Individual(s)	☐ Traffic Hazards	☐ Work in Active Substation	☐ Hot Work
☐ Asbestos	☐ Ladder	☐ Trenches Excavations	☐Animals/Insects	☐ Radioactive Materials
☐ Dust	☐ Lighting	☐ Utilities	☐Plants	☐ Boom/Scissor Lift
☐ Edges/Material Handling	☐ Manual Lifting	☐ Water/Boat Safety	☐ ________________	☐ ________________
☐ Electricity	☐ Pressurized Fluids/Gases	☐ Weather (hot/cold)	☐ ________________	☐ ________________

List all hazards associated with this task	Signature of Crew Members Present	
	Print Name	Sign Name
Barriers to eliminate/control above hazards?		

Supervisor Signature:

Post Task Safety Analysis

Did any injuries or incidents occur today? If yes, explain.
☐ Yes ☐ No
Was the injury or incident reported the safety department?
☐ Yes ☐ No ☐ N/A
What problems did you have with today's work assignment?
What can we do tomorrow to improve performance?

Appendix F
WorkCare Program Information

FACT SHEET

WorkCare — Making Health Count

EARLY INCIDENT INTERVENTION®

Immediate Access to Medical Advice for Work Related Incidents

(888) 449-7787

INTRODUCTION

WorkCare, Inc. (WorkCare) and TRC have partnered together to promote Incident Intervention®, a resource designed to support company safety goals/targets—while reducing runaway-costs associated with workplace injuries and illnesses.

PURPOSE

Early Incident Intervention provides TRC employees with **IMMEDIATE** telephonic access to WorkCare clinicians at the time of a presumed, non-emergency workplace injury or illness. Clinicians provide expert guidance on the evaluation of symptoms, appropriate first aid, and the need for additional medical evaluation or treatment.

When utilizing this service within the first hour of an incident, known as the "Golden Hour," licensed medical staff can guide the case so that medical evaluation and treatment are rendered appropriately.

"…helps the worker traverse the unpredictable terrain of work-related injuries and illness."

PRINCIPLES OF EARLY INCIDENT INTERVENTION

- Utilizes principles of the "Golden Hour."
- Provides workers immediate clinician support at the time of an incident.
- Focuses on providing the right care, at the right time in the proper setting.

BENEFITS FOR EMPLOYEES

- Instant access to a medically qualified professional for evaluation of symptoms and possible outcomes.
- Professional guidance on appropriate first aid measures and medications.
- Professional advice regarding the need for additional medical evaluation or treatment.

BENEFITS FOR TRC

- Point of contact for emergency and non-emergency medical clinicians.
- Triages the incident to determine risk and urgency, delivering interventions that are consistent with medical guidelines for the specified injury and illness.
- Maintains communication with clinicians to ensure accurate and timely reporting.

Appendix G
Safe Catch Form

Safe Catch Report

A "Safe Catch" is a potential hazard or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries. It is everyone's responsibility to report and/or correct these potential incidents immediately. Please complete this form as a means to report these "Good Catch" situations and submit to your local OSC Representative and Mike Glenn, SVP/National Safety Director.

Complete ALL field entries:

Employee Name:		Date:	
Location:		Office:	
Project Number:		Practice:	

Conditions

Please check all appropriate conditions:

☐ Unsafe Act ☐ Unsafe Condition ☐ Unsafe Equipment ☐ Unsafe Use of Equipment

Description of Incident or Potential Hazard:

Task Performed at Time of Incident:

Causes (Primary and Contributing):

Corrective Action(s) Taken (remove the hazard, replace, repair, or retrain):

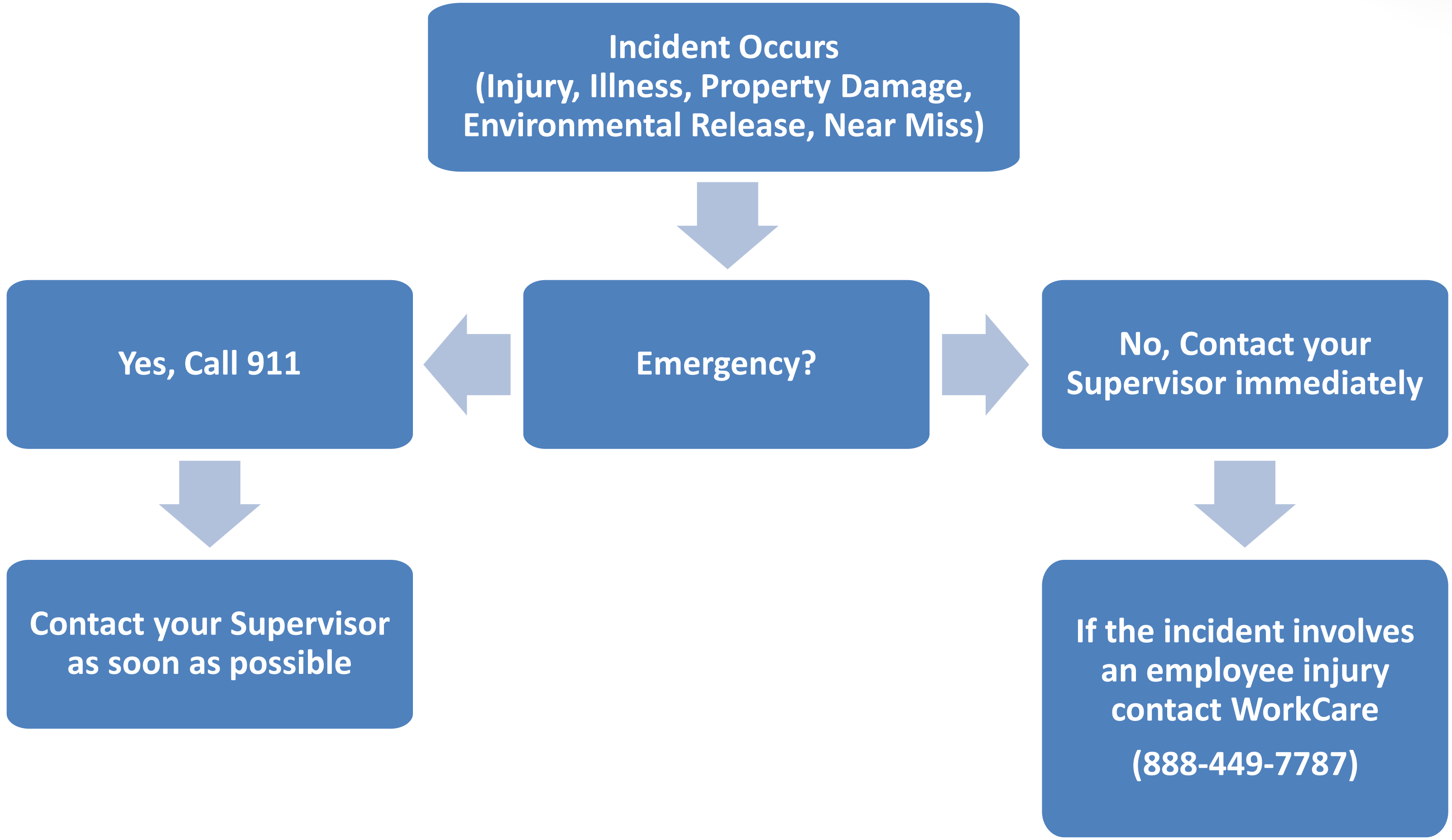
Employee Signature:		Date Completed:	

Our Mission: To reduce the frequency of incidents by applying local lessons learned globally.

If you have any questions about this report or would like additional information, please reference Compliance Program CP019 TRC Incident Response and Lessons Learned Program, located on TRCNET or contact Mike Glenn, SVP/National Safety Director at mglenn@trcsolutions.com.

Appendix H
In Case of Emergency and Incident Reporting

Incident Response Flow Chart - Employees



In Case of Injury at Work

1

If emergency care **is** needed, or if you are in a motor vehicle incident, call 9-1-1.

2

If emergency care **is not** needed, notify your supervisor **prior** to the initial contact with **WorkCare (888.449.7787).**

3

Supervisor must notify a Corporate Health and Safety Team Member.

Submit the appropriate form(s): TRC Incident Notification Report or TRC Auto Incident Report **within 24 hours** to Mike Glenn, VP, National Safety Director.

TRC
Results you can rely on

Appendix I
Job Safety Analysis Forms

Job Safety Analysis Template

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State) **TRC**	DATE PREPARED FOR HASP:	☐ NEW ☐ REVISED
JSA WORK ACTIVITY (Description):	List of Contractor(s) and key work activity:	

SITE SPECIFIC JSA AUTHOR	**POSITION / TITLE**	**DEPT**	**SIGNATURE**

TRC HEALTH AND SAFETY MANAGEMENT	**POSITION / TITLE**	**APPROVAL DATE**

PERSONAL PROTECTION EQUIPMENT (PPE) QUICK SUMMARY
Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

____ REFLECTIVE VEST ____HARD HAT _____GLOVES: **ANSI Cut Level ____ Kevlar** ____SAFETY GLASSES ______GOGGLES ______FACE SHIELD	_____ HEARING PROTECTION ____SAFETY SHOES: Protective Toe _____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ____Tyvek Suit ____Nomex ____Other (specify):	RESPIRATORY PROTECTION: ☐ NA ____½ face Air Purifying Respirator (APR) _____Particulate Mask: ☐ PM100 ☐ PM95 _____ Cartridge: ☐ P100-Multigas ☐ _______________ _____Full face ARP; specify cartridge type: _____ Air Supplied Respirator ____SCBA _____Air-line	Additional PPE: .

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day.
Focus on each new task, procedures, and skill sets to be used.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1)	a.	
	b.	

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.		
[1] JOB TASKS	**[2] POTENTIAL HAZARDS**	**[3] HAZARD CONTROLS (beyond wearing "Required" PPE)**
2)		
3)		

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
3)		
4)		
	LOCATION(S) WHERE HAZARD IS TO BE EXPECTED	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1.	a.	a.
2.	a.	a.
3.	a.	a.

Field Notes:

____

____

LIMITATION: As part of TRC's EHS Policy, a JSA is provided by TRC for its employees. The purpose of a JSA is NOT to identify all hazards associated with a task, but to identify key potential hazards to get TRC and other onsite personnel thinking about other potential safety hazards and mitigating actions for unsafe conditions and behavior during various works. TRC recognizes that JSA's may not cover every conceivable step or hazard that emerges during a job, so we've provided a "Field Change" section below to amend a JSA if required. The JSA does not supersede or replace any local, state or federal permit, regulation, statute or other entities policies and procedures but is simply a tool for enhancing the execution of safe work at a jobsite under TRC's supervision. Similarly, all subcontractors are required to provide their own JSA(s) for their specialty prior to performing any work for TRC or its customers in accordance with TRC's EHS Policy; however, any unsafe condition or hazard not covered in any JSA is ultimately the direct responsibility of the person or entity performing the work.

Appendix J
Acknowledgement

PERSONAL ACKNOWLEDGEMENT

A component of the HASP, designed to provide personnel safety during work activities described herein, requires that you receive training as described in the HASP prior to working at this site. Additionally, you are required to read and understand the HASP. When you have fulfilled these requirements, please sign and date this personal acknowledgement:

Name (Printed)	Signature	Date

Appendix D
Generic Community Air Monitoring Plan and Fugitive Dust and Particulate Monitoring Program

Appendix 1A
New York State Department of Health
Generic Community Air Monitoring Plan

Overview

A Community Air Monitoring Plan (CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

The generic CAMP presented below will be sufficient to cover many, if not most, sites. Specific requirements should be reviewed for each situation in consultation with NYSDOH to ensure proper applicability. In some cases, a separate site-specific CAMP or supplement may be required. Depending upon the nature of contamination, chemical- specific monitoring with appropriately-sensitive methods may be required. Depending upon the proximity of potentially exposed individuals, more stringent monitoring or response levels than those presented below may be required. Special requirements will be necessary for work within 20 feet of potentially exposed individuals or structures and for indoor work with co-located residences or facilities. These requirements should be determined in consultation with NYSDOH.

Reliance on the CAMP should not preclude simple, common-sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

Community Air Monitoring Plan

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for VOCs and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary. Most sites will involve VOC and particulate monitoring; sites known to be contaminated with heavy metals alone may only require particulate monitoring. If radiological contamination is a concern, additional monitoring requirements may be necessary per consultation with appropriate DEC/NYSDOH staff.

Continuous monitoring will be required for all ground intrusive activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells.

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) on a continuous basis or as otherwise specified. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions, particularly if wind direction changes. The monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

1. If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

2. If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

3. If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.

4. All 15-minute readings must be recorded and be available for State (DEC and NYSDOH) personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations should be monitored continuously at the upwind and downwind perimeters of the exclusion zone at temporary particulate monitoring stations. The particulate monitoring should be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment must be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration should be visually assessed during all work activities.

1. If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

2. If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

3. All readings must be recorded and be available for State (DEC and NYSDOH) and County Health personnel to review.

December 2009

Appendix 1B
Fugitive Dust and Particulate Monitoring

A program for suppressing fugitive dust and particulate matter monitoring at hazardous waste sites is a responsibility on the remedial party performing the work. These procedures must be incorporated into appropriate intrusive work plans. The following fugitive dust suppression and particulate monitoring program should be employed at sites during construction and other intrusive activities which warrant its use:

1. Reasonable fugitive dust suppression techniques must be employed during all site activities which may generate fugitive dust.

2. Particulate monitoring must be employed during the handling of waste or contaminated soil or when activities on site may generate fugitive dust from exposed waste or contaminated soil. Remedial activities may also include the excavation, grading, or placement of clean fill. These control measures should not be considered necessary for these activities.

3. Particulate monitoring must be performed using real-time particulate monitors and shall monitor particulate matter less than ten microns (PM10) with the following minimum performance standards:

(a) Objects to be measured: Dust, mists or aerosols;
(b) Measurement Ranges: 0.001 to 400 mg/m3 (1 to 400,000 :ug/m3);
(c) Precision (2-sigma) at constant temperature: +/- 10 :g/m3 for one second averaging; and +/- 1.5 g/m3 for sixty second averaging;
(d) Accuracy: +/- 5% of reading +/- precision (Referred to gravimetric calibration with SAE fine test dust (mmd= 2 to 3 :m, g= 2.5, as aerosolized);
(e) Resolution: 0.1% of reading or 1g/m3, whichever is larger;
(f) Particle Size Range of Maximum Response: 0.1-10;
(g) Total Number of Data Points in Memory: 10,000;
(h) Logged Data: Each data point with average concentration, time/date and data point number
(i) Run Summary: overall average, maximum concentrations, time/date of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration and time/date occurrence, averaging (logging) period, calibration factor, and tag number;
(j) Alarm Averaging Time (user selectable): real-time (1-60 seconds) or STEL (15 minutes), alarms required;
(k) Operating Time: 48 hours (fully charged NiCd battery); continuously with charger;
(l) Operating Temperature: -10 to 50^{o} C (14 to 122^{o} F);
(m) Particulate levels will be monitored upwind and immediately downwind at the working site and integrated over a period not to exceed 15 minutes.

4. In order to ensure the validity of the fugitive dust measurements performed, there must be appropriate Quality Assurance/Quality Control (QA/QC). It is the responsibility of the remedial party to adequately supplement QA/QC Plans to include the following critical features: periodic instrument calibration, operator training, daily instrument performance (span) checks, and a record keeping plan.

5. The action level will be established at 150 ug/m3 (15 minutes average). While conservative,

this short-term interval will provide a real-time assessment of on-site air quality to assure both health and safety. If particulate levels are detected in excess of 150 ug/m3, the upwind background level must be confirmed immediately. If the working site particulate measurement is greater than 100 ug/m3 above the background level, additional dust suppression techniques must be implemented to reduce the generation of fugitive dust and corrective action taken to protect site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection for on-site personnel and implementing additional dust suppression techniques (see paragraph 7). Should the action level of 150 ug/m3 continue to be exceeded work must stop and DER must be notified as provided in the site design or remedial work plan. The notification shall include a description of the control measures implemented to prevent further exceedances.

6. It must be recognized that the generation of dust from waste or contaminated soil that migrates off-site, has the potential for transporting contaminants off-site. There may be situations when dust is being generated and leaving the site and the monitoring equipment does not measure PM10 at or above the action level. Since this situation has the potential to allow for the migration of contaminants off-site, it is unacceptable. While it is not practical to quantify total suspended particulates on a real-time basis, it is appropriate to rely on visual observation. If dust is observed leaving the working site, additional dust suppression techniques must be employed. Activities that have a high dusting potential--such as solidification and treatment involving materials like kiln dust and lime--will require the need for special measures to be considered.

7. The following techniques have been shown to be effective for the controlling of the generation and migration of dust during construction activities:

(a) Applying water on haul roads;
(b) Wetting equipment and excavation faces;
(c) Spraying water on buckets during excavation and dumping;
(d) Hauling materials in properly tarped or watertight containers;
(e) Restricting vehicle speeds to 10 mph;
(f) Covering excavated areas and material after excavation activity ceases; and
(g) Reducing the excavation size and/or number of excavations.

Experience has shown that the chance of exceeding the 150ug/m3 action level is remote when the above-mentioned techniques are used. When techniques involving water application are used, care must be taken not to use excess water, which can result in unacceptably wet conditions. Using atomizing sprays will prevent overly wet conditions, conserve water, and provide an effective means of suppressing the fugitive dust.

8. The evaluation of weather conditions is necessary for proper fugitive dust control. When extreme wind conditions make dust control ineffective, as a last resort remedial actions may need to be suspended. There may be situations that require fugitive dust suppression and particulate monitoring requirements with action levels more stringent than those provided above. Under some circumstances, the contaminant concentration and/or toxicity may require additional monitoring to protect site personnel and the public. Additional integrated sampling and chemical analysis of the dust may also be in order. This must be evaluated when a health and safety plan is developed and when appropriate suppression and monitoring requirements are established for protection of health and the environment.

TRC

GENERIC FIELD ACTIVITIES PLAN

STANDBY ENGINEERING SERVICES
CONTRACT NO: D009812

Prepared for:

NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, New York 12233

Prepared by:

TRC Engineers, Inc.
1430 Broadway
New York, New York 10018

JUNE 2020

RECORD OF REVISIONS

Revision No.	Revision Date	Summary of Revision	Modified by
0	06/17/2020	New document	J. King

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

This Generic Field Activities Plan (FAP) has been developed for use on work assignments issued to TRC Engineers, Inc. (TRC) under New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation (DER), Standby Engineering Contract No. D009812. Compliance with this Generic FAP, and associated documents, is required for all TRC personnel working on NYSDEC project sites and/or conducting NYSDEC project field work. This Generic FAP has been prepared to meet the requirements specified in the contract and includes the following:

- Objectives of the FAP (Section 1.1)
- Responsibilities of the Consultant (Section 1.0)
- Description and Rationale of Field Activities (Section 1.2)
- Direct Push/Geoprobe® Drilling Procedures (Section 5.1.1)
- Monitoring Well Installation and Construction Procedures (Section 5.3, Appendix A, RMD007)
- Monitoring Well Development Procedures (Section 5.3, Appendix A, ECR006)
- Groundwater Monitoring and Sampling Procedures (Section 8.2, Appendix A, ECR009)
- Exploratory Test Pit/Trench Procedures (Section 5.2, Appendix A, RMD012)
- Sediment Sampling Procedures (Section 7.0, Appendix A, RMD008)
- Soil Vapor Point Installation and Sampling Procedures (Section 4.2, Appendix A, ECR015)
- Indoor Air Monitoring Program (Section 4.3, Appendix A, ECR024)
- Community Air Monitoring Program (Section 4.1, NYSDEC DER-10)
- Storage and Disposal of Waste Procedures (Section 12.0 and Section 16.0)
- Site Survey and Base Map Preparation Procedures (Section 2.0)
- Additional information related to anticipated field activities under the scope of work (SOW) (Sections 2.0 through 16.0)

1.1 Objective and Scope of the Generic Field Activities Plan

The objective of this Generic FAP is to specify field investigation and sampling procedures to be used on work assignments under the contract and provide general information on elements of field investigations. TRC's approach for implementing field investigations includes field sampling activities designed to confirm the presence or absence of contaminants of concern attributable to past and present operational and/or storage activities at the site, and to quantify the concentrations of potential contaminants of concern through field screening and laboratory analysis. Information relating to site-specific investigations will be presented in the work assignment (WA) packages. The work assignment specific field programs may include some or all of the field activities listed in **Section 1.0**. Changes or revisions to the investigation and sampling procedures provided in this Generic FAP, together with the rationale for these changes, will be included in the WA packages.

1.2 Rationale

The rationale for performance of field activities will be based on the identification and delineation of source and extent of contamination as well as the identification of potential receptors and migration pathways, while obtaining practical information for use in the evaluation of remedial technologies and selection of a remedial plan. The approach will provide for a cost-effective field program and allow for accelerated development of a remediation plan for the site

1.3 Generic Field Activities Plan Review and Amendments

This Generic FAP will be reviewed periodically for compliance with applicable laws, rules, regulations, guidance, etc. and applicability to project sites, field activities, and work assignment issuances under the contract. The individual responsible for reviewing the Generic FAP will be TRC's Quality Assurance Officer (QAO). The following components will be reviewed periodically.

- Generic FAP language
- Applicable regulations, standards, guidance, policies, etc.
- TRC Standard Operating Procedures (SOPs) provided in **Appendix A**
- TRC field forms provided in **Appendix B**

The Generic FAP will undergo a complete review (and/or amendment as appropriate) at the following frequencies:

- Annually
- Change in applicable regulations, standards, guidance, policies, etc.
- Change in TRC SOPs
- Upon NYSDEC request

Generic FAP modifications will be made within 60 calendar days after discovery, observation, or event requiring the review. If revisions and/or changes are made to the Generic FAP, such revisions will be described in the **Record of Revisions** and provided to the NYSDEC for review and approval. Implementation of the new or modified field activity procedures will be initiated immediately upon NYSDEC approval.

1.4 TRC Standard Operating Procedures

Where applicable and appropriate to activities to be conducted on behalf of the NYSDEC, TRC SOPs have been included with this Generic FAP in **Appendix A**. The SOPs contained therein are identified in appropriate sections of the Generic FAP text, and are listed in **Table A-1** of **Appendix A**.

1.5 TRC Field Documentation

When TRC conducts field activities on behalf of the NYSDEC, a field logbook containing the pertinent project information and detailing daily activities will be maintained. Further details regarding field logbooks and information contained therein can be found in the TRC SOP RMD001 Field Activity Documentation for Environmental Investigations, which is included in **Appendix A**.

In addition to daily documentation in the field logbook, TRC will utilize field forms to record various sample media observations and/or instrument measurements. The forms to be utilized by TRC personnel are provided in **Appendix B**. A table summarizing the forms contained therein are listed in **Table B-1** of **Appendix B**.

Alternatively, mobile data collection and documentation may be utilized using applications developed for the intent of documenting field activities including but not limited to, groundwater gauging and sampling, soil logging, remedial activities field reports and building assessments.

1.6 Applicable Regulatory Guidance

In addition to the TRC SOPs outlined above, field activities and will be completed in accordance with guidance provided by the NYSDEC, New York State Department of Health (NYSDOH), and the United States Environmental Protection Agency (USEPA), where applicable. As such, general regulatory documents governing anticipated field activities include:

- NYSDEC CP-43 – Groundwater Monitoring Well Decommissioning Policy, November 2009;
- NYSDEC DER-10 – Technical Guidance for Site Investigation and Remediation (DER-10), May 2010;
- NYSDEC – Guidelines for Sampling and Analysis of PFAS Under NYSDEC's Part 375 Remedial Programs, January 2020;
- NYSDEC – Sampling for 1,4-Dioxane and PFAS Under NYSDEC's Part 375 Remedial Programs, February 2019;
- NYSDOH Center for Environmental Health (CEH) Bureau of Environmental Exposure Investigation (BEEI) Guidance for Evaluating Soil Vapor Intrusion (SVI) in the State of New York, amended May 2017;
- New York State Department of Labor (NYSDOL) Industrial Code Rule 56 – Asbestos, March 2007;

- USEPA Office of Soil Waste and Emergency Response (OSWER) Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, June 2015;
- 6 New York Code of Rules and Regulations (NYCRR) Part 360 – Solid Waste Management Facilities, December 2019;
- 6 NYCRR Part 375 – Environmental Remediation Programs, December 2006;
- American Society for Testing and Materials (ASTM) Method D422, Method D1140, and Method D4318;
- 29 Code of Federal Regulations (CFR) 1926.62 – Occupational Safety and Health Administration (OSHA) Lead in Construction;
- 40 CFR Part 273 and 6 NYCRR Section 374.3; and
- NYSDEC Fish and Wildlife Impact Analysis for Inactive Waste Sites (October 1994).

The inclusion of new or additional regulatory documents will be appended to this section following the condition warranting this Generic FAP's review, as outlined in **Section 1.3**.

2.0 SITE SURVEY

2.1 Site Survey/Base Map

A base map will be prepared by a New York State licensed surveyor for horizontal and vertical control to map relevant features on the site including property boundaries, structures, roads, previous excavations, and existing piezometers and monitoring wells. The base map will be developed by integrating survey data with available geographic information system (GIS) information and aerial photography wherever possible. During site characterization activities, the base map will be used to plot environmental sampling locations, including but not limited to, soil borings, monitoring wells, sample locations, and any other items of interest noted during the field work. Horizontal and vertical coordinates for physical structures, sampling locations, piezometers, and monitoring wells will be integrated into the base map. Vertical and horizontal control of the monitoring well/piezometer casing will allow for calculation of groundwater elevations for the development of groundwater surface elevation contour maps. The surveyor will establish elevations with respect to benchmarks in the vicinity of the site property. Vertical measurements will be referenced to the North American Vertical Datum of 1988 (NAVD 88) and be reported to within approximately 0.01 feet.

Horizontal control will be established by traverse runs to establish location with respect to the New York State planar coordinate grid system and be provided in New York State planar and Universal Transverse Mercator (UTM) coordinates (NAVD 88). Horizontal traverses will be tied into established benchmarks. Horizontal transverse runs will be tied back to initial control points as a check for closure, and error of closure will be recorded. The horizontal locations of physical structures, sampling points, and other items of interest will be reported to within approximately 0.1 feet.

Control points for use in the preparation of a topographic map of the study area will also be surveyed, if necessary. Coordination with the surveyor will be required in order to select the necessary control points for preparation of the topographic map using aerial photography.

In addition, for the purposes of supplying the NYSDEC with the appropriate coordinates required for inclusion in their EQuIS database, all sample locations will be designated with the appropriate latitude and longitude values.

When deemed appropriate and necessary, sampling points, and physical site features may be established with a Global Positioning System (GPS) field survey unit that can locate points within remote and overgrown areas using an extension pole-mounted receiver that can be held above the vegetation by field personnel. When possible, the coordinates for each sample location will be pre-programmed into the GPS Asset Surveyor as waypoints for use in navigating to the location in the field. The horizontal locations of physical structures, sampling points, and other items of interest will be reported to within approximately 3 feet.

2.2 Utility Survey

Above and underground utilities, including but not limited to electric lines, gas lines, water lines, and communication lines will be identified prior to initiation of drilling and other subsurface work. On-site underground utilities in the vicinity of subsurface intrusion points will be located through the performance of a utility survey. The utility mark out will be performed using non-intrusive ground penetrating radar (GPR) and radio frequency (RF) utility locating techniques. Any off-site underground utilities in public rights of way (ROW) will be located and marked by a representative of the One Call Center, as required by New York Code 753. Any subsurface utilities will be identified on the ground surface with spray paint, in accordance with the American Public Works Association (APWA) utility color codes.

2.3 Geophysical Survey

A geophysical survey will be conducted to identify subsurface features and buried utilities beneath a site when it is deemed appropriate and necessary based on site history or site observations prior to undertaking any intrusive activities. An approach to developing an investigatory strategy will consist of the identification and location of areas of concern (AOCs) for each type of physical structure or feature suspected to be buried beneath the site. To meet these objectives, the following techniques may be employed:

- Terrain Conductivity Electromagnetic (EM) Method – EM response to metal makes this technique suitable for the identification of buried metal objects such as underground storage tanks (USTs), utilities, drums, and equipment. The EM method is sensitive to metal objects near the ground surface, in addition to some naturally occurring geologic features.
- RF Utility Locating Method – An RF utility locating system consisting of a receiver/tracer and remote transmitter may be used to identify active underground electrical or communication lines.
- GPR Method – A GPR system may be used to confirm the location of utilities and identified buried features using RF and EM methods, and – if the site geology permits - to search for non-metallic utilities or objects, such and fiberglass, polyvinyl chloride (PVC), or other plastic piping.

3.0 GENERAL SAMPLING REQUIREMENTS

3.1 Chain of Custody and Sample Shipping Procedures

Environmental samples collected during site characterization/investigation will be properly labeled, packaged, preserved and shipped under chain of custody (COC) procedures to an NYSDOH Environmental Laboratory Accreditation Program (ELAP)-approved laboratory. Further information on this process is included in the Generic Quality Assurance Project Plan (QAPP) and in the following TRC SOPs located in **Appendix A**:

- TRC SOP RDM002 Chain of Custody Procedures
- TRC SOP ECR023 Packaging and Shipping of Non-Hazardous Environmental Samples

3.2 Sampling Equipment Decontamination

Sampling equipment will be decontaminated to remove potential contaminants prior to and between collection of samples. TRC procedures for the decontamination of sampling equipment are outlined in TRC SOP ECR010 Equipment Decontamination, which is included in **Appendix A**.

4.0 AIR SAMPLING

4.1 Community Air Monitoring Plan

During ground intrusive activities, air monitoring for volatile organic compounds (VOCs) and particulate matter will be accomplished at the upwind and downwind Exclusion Zone (EZ) perimeter to document real time contaminant and dust levels potentially migrating away from the work area. All Community Air Monitoring Plan (CAMP) activities, response levels, and actions will be in accordance with requirements of NYSDEC DER-10, Appendices 1A and 1B, NYSDOH Generic CAMP and Fugitive Dust and Particulate Monitoring, respectively.

The following will be used as a general guide for the number of CAMP stations to be used at a project site based on the type and extent of ground intrusive activities:

- Drilling/Direct Push Activities – 1 upwind and 1 downwind
- Test Pits/Small Exploratory Excavations – 1 upwind and 2 downwind
- Site Clearing/Remedial Excavations/Treatment Activities – 1 upwind and 3 downwind
- Additional configurations of upwind and downwind stations as needed based upon field activities potential hazards, site conditions/setting and/or NYSDEC/NYSDOH request

In addition to continuous monitoring during ground intrusive activities, periodic monitoring for VOCs will also be conducted during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from monitoring wells.

Further details regarding site monitoring procedures including instrumentation, CAMP protocol, and off-site contaminant migration procedures can be found in TRC's Generic Health and Safety Plan (HASP).

4.2 Soil Vapor Sampling

Soil vapor sampling will be performed to evaluate the concentrations of volatile compounds in the vadose zone beneath the floor of a building or other AOC. Where applicable to the installation of temporary or permanent sub slab points, TRC will utilize the Vapor Pin® device. The procedure for a soil vapor survey is outlined in the TRC SOP ECR015 Soil Vapor Point Installation and Active Vapor Sampling, which is included in **Appendix A**. Additionally, SOPs detailing the installation of the Vapor Pin® device can also be found in **Appendix A**.

4.3 Indoor/Ambient Air Sampling

The sampling of indoor air will be necessary to evaluate whether volatile compounds from the vadose zone have migrated into buildings located above impacted soil and/or groundwater. The procedure for an indoor/ambient air survey is outlined in the TRC SOP ECR024 Indoor and Ambient Air Sampling, which is included in **Appendix A**. Additionally, the NYSDEC document entitled Structure Sampling Questionnaire and Building Inventory, provided in **Appendix B**, will be used to document and assess any potential interfering conditions while sampling.

5.0 DRILLING METHODS, TEST PITS AND MONITORING WELL INSTALLATION

5.1 Drilling Methods

5.1.1 Direct Push Technology

Direct push technology (DPT) may be used to collect multiple soil samples at discreet intervals with minimal disturbance and is generally considered the most efficient method for vertical and horizontal delineation of soil impacts. DPT may also be utilized to collect one-time groundwater samples from a discrete interval (see **Section 8.3** for details).

The site geology and hydrogeology must be evaluated to determine if it is amenable to DPT. Probe sampling is typically only applicable in unconsolidated deposits absent of numerous cobbles, boulders, or bedrock. If these features are known or determined to be present during subsurface investigation activities, conventional drilling techniques may be required for sample collection.

5.1.2 Hollow Stem Augers

The hollow stem auger (HSA) method is among the most common drilling method for the construction of monitoring wells. HSA drill rigs are generally mobile, relatively fast in depths shallower than 40 feet below ground surface (bgs) and operate well in unconsolidated materials. Synthetic drilling fluids are not typically used and disturbance to the geologic materials penetrated is minimal. The depth to which a boring can be advanced via HSA may vary based upon the native soil type; however, borings up to 100 feet bgs and greater are possible (maximum depth limit is approximately 200 feet bgs). Clayey soils and tills can restrict the depth to which HSA drilling can be accomplished. Augers cannot be typically used in bedrock, unless it is highly weathered, and the use of HSA drilling in heaving sand environments may also present difficulty.

5.1.3 Cable Tool

The cable tool drilling method is relatively slow, but still offers advantages, such as the ability to create large diameter borings, and ability to increase permeability of bedrock. These features also make it a useful choice for monitoring well construction in unconsolidated formations and relatively shallow consolidated formations. The method allows for the collection of formation samples and the detection of permeable zones. The installation of a steel casing as drilling progresses also provides a stable annulus for the construction of a monitoring well.

5.1.4 Air Rotary

Rotary drilling methods operate on the principle of circulating either a fluid or air to remove the drill cuttings and maintain an open hole as drilling progresses. The different types of rotary drilling are named according to the type of fluid and the direction of fluid flow. Air rotary drilling forces air down the drill rods and back up the borehole to remove the drill cuttings. The use of air rotary drilling is best suited for hard rock formations. In soft, unconsolidated formations, a casing is driven to keep the formations from caving. In highly fractured formations, it is often difficult to maintain air circulation and casing may be required. The air from the compressor on the rig must be filtered to ensure that the oil from the compressor is not introduced into the geologic formation and cross contaminate the area. The use of air rotary drilling techniques must be used with care in highly contaminated or hazardous environments. Contaminated solids, water and vapors can be ejected out of the hole and are difficult to contain. Additional protective measures for the drill crew and observers are required. Casing can be used to minimize the potential issues associated with air rotatory drilling.

5.1.5 Mud Rotary

Mud rotary drilling operates in the same fashion as the air rotary drilling technique, except that water and drilling mud are circulated down the drill pipe and back up the borehole to remove drill cuttings. Mud rotary drilling offers better control of contaminated cuttings and water removed from the boring and does not cause exposure to vapors as in air rotary techniques. The borehole is held open by the hydrostatic pressure of the circulating mud and the mud cake, that develops on the borehole wall during the drilling process. Viscosity of the drilling mud is controlled to minimize the infiltration of the drilling fluid into porous formations penetrated by the drilling equipment. The use of drilling mud can cause groundwater chemistry or in-situ permeability to be altered by introduction of mud into the borehole. Monitoring wells installed in mud-rotary borings often require extra well development and may detect solutes attributable to the mud that cause an inaccurate assessment of groundwater chemistry at least initially. Under certain conditions, mud rotary techniques can be effective by using a continuous supply of potable water without additives. Alternatively, mud can be used to advance a boring to a depth several feet above the zone of interest, at which time mud can be replaced with potable water and the borehole continued to final depth.

5.1.6 Sonic Drilling

Sonic drilling is similar to DPT in that a core barrel is advanced through the soil, collecting a soil sample core. However, rather than using vertical downward force to advance the drill, Sonic uses high-frequency vibrations to move soil particles out of the path of the drill tip. As a result, it is effective in unconsolidated sands and gravels, and can produce a continuous core sample for classification and analysis. Further, some rigs can advance a 6-inch diameter borehole to a depth of up to 1,000 feet bgs in a short period of time when compared to other drilling techniques.

5.1.7 Bedrock Coring

Rock core samples (NX diameter or larger) will be collected in 5-foot or 10-foot runs starting at the top of competent bedrock and extending to depths determined in the site-specific SOW. Rock Quality Designation (RQD) will be determined for each core by dividing the total length of the core by the total length of recovered segments greater than 4 inches in length, exclusive of any mechanical (drilling induced) fractures. RQD is useful in quantifying the degree of fracturing for a given segment of a rock formation. Rock cores will be collected for logging purposes only and will not undergo chemical analysis. Bedrock logging will include observations regarding drilling rate, drill water recovery, sudden drops in drill tools, and lithology of rock cores.

5.2 Test Pits

Test pits will be excavated using a backhoe or excavator with an appropriate reach. The location, depth and dimensions of test pits will be recorded along with the descriptions of the excavated material. Limits of waste and grossly contaminated soil, when encountered, will be clearly marked in the field for future surveying. At each location material excavated will be returned to the excavation using a "last out – first in" sequence. The procedure for excavating and closing a test pit are outlined in TRC SOP RMD012 Test Pit Investigations, included in **Appendix A**.

5.3 Monitoring Well Installation/Development

The selection of drilling and monitoring well construction methods will be based on site-specific conditions, including geologic materials to be penetrated, anticipated drilling depth, cross-contamination potential, and site accessibility. The selection of an appropriate drilling method for monitoring well construction will be based on minimizing both the disturbance of subsurface soils and the introduction of air, fluids, and muds. The use of drilling muds and chemical additives will be avoided, where possible, as the introduction of any foreign material has the potential for interfering with the groundwater chemical quality.

For further information regarding monitoring well installation and development techniques, see the following TRC SOPs located in **Appendix A**:

- TRC SOP RMD007 Groundwater Monitoring Well Installation
- TRC SOP ECR006 Well Development

6.0 SOIL SAMPLING

Soil samples will be collected using a variety of methods, depending on depth, soil type, and accessibility. The methods used for soil sampling are outlined in the TRC SOP ECR003 Soil Sampling, which is included in **Appendix A**.

6.1 Surface Soil

The depth of surface soil samples will be determined on a site-specific basis and may be influenced by site-specific conditions, investigation objectives, AOCs, contaminants of concern and potential exposure pathways. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches bgs. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 2 inches for risk assessment purposes or a deeper soil interval from 12 to 24 inches bgs when assessing the impact of soil contamination on ecological resources.

6.2 Subsurface Soil

Subsurface soil sample samples will generally be collected via soil borings and/or test pitting for laboratory analysis (chemical and geotechnical) and to provide a profile of subsurface conditions in identified or suspected AOCs and in other areas as needed to characterize the site. Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), COCs, and the soil type. Near-surface soils may be sampled using hand tools, such as a hand auger, spade or post-hole digger. Sampling at greater depths typically is performed using an HSA, a split-spoon, DPT (i.e., Geoprobe®), sonic drilling, a backhoe or an excavator.

7.0 SURFACE WATER, SEDIMENT AND WETLAND SAMPLING

Each project site will be evaluated to determine if surface water bodies or wetlands are located on or near the site. If a surface water body or wetland is located on or near the site, the field investigation program will evaluate whether the following have occurred or are occurring:

- Contaminated surface soil is present near the ground surface in the vicinity of the surface water body or wetland;
- Contaminated groundwater flows to the surface water body or wetland;
- Waste discharge from the site to the surface water body or wetland;
- Historic waste disposal from the site to the water body or wetland; and
- Contaminated sediment, soil or surface water are present within the water body or wetland.

If there is evidence the surface water, sediment or wetland may have been impacted by contamination emanating from the project site, further investigation may be required. For these investigations surface water and sediment samples will be collected as per TRC SOP RMD008 Surface Water and Sediment Sampling, which is included in **Appendix A**.

8.0 GROUNDWATER SAMPLING

8.1 Groundwater Level and Product Measurement

Measurement of groundwater and/or product levels will be completed as per TRC SOP ECR004 Water Level and Product Measurements, which is included in **Appendix A**.

8.2 Monitoring Well Sampling

Groundwater sampling procedures are outlined in the following TRC SOPs, which are included in **Appendix A**:

- TRC SOP ECR009 Groundwater Sampling
- TRC RMD011 Calibration of Field Instruments for Water Quality Parameters

8.3 Specialty Groundwater Sampling Techniques

In order to define the horizontal and vertical extent of groundwater contamination associated with a site, groundwater sampling may be necessary in locations that do not contain previously existing monitoring wells. In such cases, groundwater samples may be collected using small diameter temporary monitoring wells, push ahead type groundwater probes or modular packer assemblies. In each instance, the groundwater sampling procedures outlined above in **Section 8.2**, will be followed. Using the below referenced techniques may result in some limitations. For example, obtaining groundwater samples in fine-grained soils, such as clays and silts, may require excessive collection times and cause high turbidity. In heterogeneous formations, bypassing contaminant zones entirely or spreading contaminant zones is another drawback of these methods.

8.3.1 Small Diameter Temporary Monitoring Wells

Small diameter temporary monitoring wells may be constructed using the protected-screen method (i.e., the well casing and screen are either advanced within or lowered into a protective outer drive rod that has already been driven to the target depth) or the exposed-screen method (the well casing and screen are driven to the target depth using a single string of rods with no filter pack or well seal). For the protected-screen method, an outer drive casing equipped with an expendable drive tip will be advanced to the target depth. The well casing and screen will then be assembled, lowered inside the drive casing, and anchored to the drive tip. A sand filter pack will be poured or tremied into place as the drive casing is removed. Alternatively, a "pre-packed" or "sleeved" well screen can be used for better control of filter pack placement and grain size. Bentonite pellets or chips or a bentonite/cement slurry will then be placed as the drive casing is removed from the hole. Similar to the "pre-packed" and "sleeved" screens, modular bentonite sleeves that attach to the well screens and are advanced with the well during installation may also be used.

8.3.2 Push Ahead Type Groundwater Probes

There are several push ahead type groundwater probes available to collect depth-discrete groundwater samples from multiple intervals in the same soil boring. Each probe type may have one or more unique aspects of operation; however, most probes function as retractable protected-screen samplers. Probes typically consist of an adjustable (e.g., 6-inch to 40-inch) stainless steel or PVC screen within a sealed, water-tight tool body. Because the screen is not exposed to the formation as the probe is advanced into the subsurface, the screen does not become plugged, contaminated or damaged. To collect a sample, the probe will be driven into the formation at the end of a single rod or at the end of a single rod inside a drive casing until the sampler tip is approximately 1 foot below the target sampling depth. Once that depth has been reached, the expendable drive point will be disengaged, and the rod pulled back to expose the screened sampler. Disposable polyethylene tubing equipped with a foot valve, small diameter bailer, peristaltic pump, or other device will be used to convey groundwater to the surface for collection. Each sample, upon retrieval, will be measured in the field for pH, conductivity, turbidity, dissolved oxygen (DO), oxygen reduction potential (ORP), and temperature if feasible given the productivity of the water bearing interval.

After collection of the groundwater sample, the probe will be removed, and the boring will be continued to the next sampling interval. Prior to collecting the next sample, the probe and associated equipment will be decontaminated in accordance with the Generic QAPP and the corresponding TRC SOP. The locations and depths of probe samples will be provided in the site-specific SOW.

8.3.3 Modular Packer Assemblies

A modular packer assembly is another option for obtaining depth-discrete groundwater samples during drilling operations. These devices typically consist of a small section of stainless-steel screen within a water tight tool body and have inflatable packers situated above and below the screen. To collect a sample, the packer assembly will be lowered into the drill casing or borehole to the desired sampling depth. The packers will be inflated to seal the borehole and allow only groundwater from the desired zone to enter the screen. Once in place, the rod will be pulled back to expose the screen. Disposable polyethylene tubing equipped with a peristaltic pump or other device will be used to convey groundwater to the surface for collection. Each sample, upon retrieval, will be measured in the field for pH, conductivity, turbidity, dissolved oxygen DO, ORP, and temperature if feasible given the productivity of the water bearing interval.

After collection of the groundwater sample, the packer assembly will be removed, and the boring will be continued to the next sampling interval. Prior to collecting the next sample, the packer assembly and associated equipment will be decontaminated in accordance with the Generic QAPP and the corresponding TRC SOP. The locations and depths of the samples will be provided in the site-specific SOW.

8.4 Residential Well Sampling

The procedure for collecting groundwater samples from residential wells is outlined in TRC SOP ECR016 Residential Well Sampling, included in **Appendix A**.

9.0 SPECIALTY QUALITATIVE SCREENING TECHNOLOGIES

Examples of screening technologies include immunoassay or other colorimetric test kits, portable gas chromatography, x-ray fluorescence analyzers, and direct-sensing, down-hole devices such as the membrane interface probe. Quick turn-around analysis using a modified analytical method at a fixed or mobile laboratory is also considered to be a screening technology, unless the laboratory is ELAP-accredited to analyze samples by that method. Various screening technologies, in conjunction with rapid data interpretation and analysis by the project management team, may be used under this contract to expedite site investigations, identify "clean" delineation sample locations, select post-excavation confirmatory sample locations, collect design date for remedial actions, etc. A SOP will be included in the site-specific work plan that details the step-by-step procedures to follow including quality assurance procedures. A minimum of 10 percent of the field samples will be split and sent to an ELAP-accredited laboratory for correlation analysis. If less than 10 samples are collected, then at least three split sample will be collected for correlation analysis. The correlation will generally be considered acceptable if the field-testing results are within 30 relative percent difference (RPD) of the laboratory results. Several screening technologies which are anticipated for use under this contract are summarized below.

9.1 Membrane Interface Probe

The membrane interface probe (MIP) is a direct push tool that produces continuous chemical and physical logs of the vadose and saturated zones. The system detects VOCs in-situ and shows where impacts occur relative to the geologic and hydraulic units. As the MIP advances through the soil column, it heats the soils and groundwater adjacent to the probe to approximately 120 degrees Celsius. This increases volatility, and the vapor phase gas diffuses across a membrane into a closed, inert gas loop that carries the vapors to a series of detectors housed at the ground surface. Continuous logs are generated for each detector throughout the soil column at each boring location. The detectors used included:

- Electrical Conductivity (EC)
- Halogen Specific Detector (XSD)
- Photoionization Detector (PID)
- Flame Ionization Detector (FID)

While this tool is useful for evaluating relative differences in hydrocarbon and/or chlorinated solvent impacts in the vertical soil column at a specific boring location, it is not possible to assign a quantitative concentration value to a peak in any given borehole. Therefore, soil samples must also be collected from an adjacent borehole and sent for laboratory analyses to confirm readings observed by the MIP.

9.2 Soil Sample Screening Methods

The following methods are used in the field to provide real-time qualitative screening of soil samples collected during the installation of soil borings or monitoring wells, or during excavation activities.

9.2.1 Organic Vapor Analyzer (Total Organic Vapors)

The most common field soil screening techniques are completed using either a PID or FID. The TRC methodology for soil screening using a PID or FID is outlined in TRC SOP RMD014 Headspace Field Screening Procedure, located in **Appendix A**.

9.2.2 X-Ray Fluorescence Device (Metals)

Dry soil collected during excavation or drilling activities may be analyzed for heavy metals using a hand-held X-ray fluorescence (XRF) device. Should screening for heavy metals be necessary, TRC will follow the guidance provided by USEPA Method 6200 including only utilizing personnel who are properly trained and certified to operate the equipment.

9.2.3 Immunoassay Colorimetric Field Test Kits (PCBs)

Immunoassay Colorimetric Field Test Kits (ICFTs) are used to field screen soils via a wet chemistry method. They may be used to screen for polychlorinated biphenyls (PCBs) or various hydrocarbons. Under this contract, TRC is most likely to use ICFTs for field screening of PCBs. At least 5 percent of soil samples screened in the field will also be submitted for laboratory analyses.

9.2.4 Hydrocarbon Field Test Kits

Hydrocarbon field test kits are qualitative sampling tests for identifying the presence of hydrocarbons including light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) in soil. The tests visually enhanced the presence of oils and petroleum products in soil providing quick results. Use of the tests typically involve adding soil and water to a pre-measured test kit containing dye.

10.0 MONITORING WELL ABANDONMENT

Monitoring Wells will be abandoned in accordance with TRC SOP ECR021 Well and Borehole Abandonment/Decommissioning (**Appendix A**) and NYSDEC CP-43: Groundwater Monitoring Well Decommissioning Policy, November 2009.

11.0 GEOTECHNICAL AND IN-SITU HYDRAULIC CONDUCTIVITY TESTING

11.1 Laboratory Analyses

Laboratory analyses in association with geotechnical investigations include sieve analysis, hydrometer testing, and laboratory permeability testing. These analyses can be used to define aquifer properties or soil response to remediation methods. Collection of samples for these tests may involve retrieving minimum quantities of undisturbed samples, as required by the laboratory method, using specialized sampling tools such as a Shelby tube or Denison sampler. Samples collected for sieve and hydrometer analyses will be tested in accordance with ASTM Method D422 and ASTM Method D1140, respectively. Similarly, samples collected for permeability analyses will be analyzed in accordance with ASTM Method D4318. The need for these types of samples and analyses will be determined on a site-specific basis and contained in the site-specific SOW.

11.2 Slug Testing

Slug testing is a method used to measure the speed of recharge in order to calculate the hydraulic conductivity of the saturated subsurface. It is executed by near-instantaneous raising or lowering the water level in a well, then measuring the change in water level with time as it rebounds to the static water level. Slug testing procedures are detailed in TRC SOP ECR029 Slug Test Procedures, which is included in **Appendix A**.

11.3 Pumping Test

Pumping tests are used to measure the hydraulic conductivity and specific yield over a larger area than a slug test. Detailed pumping test procedures are outlined in TRC SOP ECR022 Pumping Tests, which is included in **Appendix A**.

11.4 Hydrocarbon Baildown Test

If NAPL is present on the site, a baildown test may be used to estimate its transmissivity. The procedure for a NAPL baildown test is outlined in the TRC SOP ECR017 Hydrocarbon Baildown Test, which is included in **Appendix A**.

11.5 Cone Penetrometer

A cone penetrometer is used for stratigraphic logging in soft soils. A cone penetrometer can measure subsurface hydraulic characteristics, including pressure head, soil permeability, and water-bearing zones. The cone penetration test involves hydraulically pushing a cone-shaped instrument into the soil and measuring its resistance to penetration. Resistance is measured by sensitive strain gauges that transmit electronic signals to a computer or datalogger. A cone penetrometer can estimate the hydraulic properties of a soil by measuring the pore pressure changes in response to the stresses created by the cone penetrometer. The use of this technology is dependent upon the characteristics of unconsolidated materials at the site. The materials must be relatively soft and free of gravel or cobbles. The need for use of a cone penetrometer test will be determined in consultation with the NYSDEC Project Manager on a site-specific basis.

11.6 Soil Classification and Geophysical Logging

The methods used by TRC to classify and log overburden soils are outlined in TRC SOP RMD005 Visual-Manual Procedure for Soil Description and Identification, which is included in **Appendix A**.

Most borehole geophysical techniques for characterizing bedrock and unconsolidated deposits fall into three categories: electrical or electromagnetic, nuclear, or acoustic/seismic methods. Additional borehole logging methods include caliper, temperature, and fluid flow logging.

The type of borehole (cased or uncased) and whether it is filled with fluid or is dry are major considerations in the selection of borehole logging techniques. Most electrical methods, for example, require an uncased borehole and either drilling fluid or water in the hole. Several different types of logs can be run in the same borehole and compared to facilitate stratigraphic interpretations. Based upon site-specific conditions and goals of the investigation, different suites of logging techniques may be used. A typical suite of logs in a fluid-filled borehole may include spontaneous potential, single point resistance, natural gamma, neutron, caliper, fluid conductivity, temperature, and acoustic velocity logging. Measurement of groundwater flow using impeller-flow meter logging equipment in boreholes is an especially useful technique for locating zones of high permeability within a borehole. Temperature logging is also useful in identifying zones of recharge to the well. Specific borehole geophysical methods will be determined on a site-specific basis and described in the site-specific SOW.

12.0 HAZARDOUS BUILDING MATERIALS SURVEY

Building surveys may be required as part of a work assignment to identify potential hazardous materials associated with on-site structures prior to investigation or demolition. If required, TRC will complete a building survey in accordance with New York State Department of Labor (NYSDOL), USEPA and United States Department of Housing and Urban Development (HUD) guidelines and regulations. The overall approach to a building survey will include the identification, evaluation and quantification of two types of concerns – Typical Facility Components and Facility-Specific Contaminants of Concern. In addition, TRC will review and utilize, as appropriate, historical building survey information provided by the NYSDEC.

The Typical Facility Components can include:

- Asbestos-Containing Materials (ACM);
- Painted surfaces potentially containing lead-based coatings;
- Construction and Demolition waste impacted by lead-based coatings and ACM;
- Flaking paint;
- PCB containing materials such as light fixture ballasts, oil-filled switches, transformers, capacitors, and caulking;
- Stained surfaces that may have been impacted by oils or PCB containing material:
- Batteries such as lead-acid, nickel cadmium, lithium and silver oxide batteries;
- Mercury containing equipment such as thermostats, hydrostats, manometers, natural gas meters, reed, float and tilt-switches;
- Lamps such as fluorescent, neon, high pressure sodium, mercury vapor, metal halide lamps;
- Drained and oil-filled electrical equipment and machinery such as transformers, circuit breakers, switches, capacitors, motors, hydraulic machinery and pumps;
- Refrigerant containing equipment such as air conditioning systems/units, refrigerators, water fountains, etc.;
- Water treatment chemicals associated with heating/cooling such as rust inhibitors, neutralizing agents and biocides;
- Storage tanks for petroleum products and chemicals;
- Fire extinguishers and fire suppression systems;
- Containers with fluids or articles such as drums;
- Waste materials and other similar items that warrant special handling and inclusion in the demolition specifications to be prepared;
- Pesticides; and
- Other potential universal wastes.

These materials fall into various categories such as Hazardous, Universal, and/or other Regulated wastes depending on the component and concentration of contaminants of concern.

Facility specific contaminants of concern are those present in facility components due to historical use and activities. Potential AOCs that require additional investigation will be identified prior to on-site survey activities.

12.1 Lead Assessment and Sampling

When beginning a building survey, TRC will conduct an initial lead paint screening throughout the building using a USEPA and State of New York licensed lead inspector. One method used for the inspection that can be utilized involves XRF, utilizing an on-site Niton XLP-300 L&K shell spectrum analyzer, or equivalent. Use of the XRF unit will be in accordance with the manufacturer's protocols for lead inspecting in construction settings. Representative measurements of the painted facility components will be conducted throughout each facility/structure to determine the general presence of any detectable amounts of lead.

TRC will collect representative samples (paint and the underlying substrate) of probable construction waste streams to determine waste disposal requirements. These samples will be analyzed for leachable lead, by the Toxicity Characteristic Leaching Procedure (TCLP).

Coated steel will not be sampled for disposal purposes, as it is exempt from lead disposal regulations if recycled by a certified recycling facility. Steel coatings will be assumed to contain lead and the abatement/demolition contractor will be required to comply with 29 CFR 1926.62, the "OSHA Lead in Construction" rule.

12.2 Asbestos Sampling

For purposes of asbestos sampling during a building inspection, only licensed NYSDOL Building Inspectors will be utilized. Unlicensed TRC or subcontractor personnel will not perform asbestos sampling at any time. Additional information on TRC asbestos inspections is included in the TRC SOP BSI003 Asbestos Inspection Procedures, located in **Appendix A**.

All asbestos bulk sampling will be performed in accordance with following federal and state regulations:

- USEPA National Emission Standards for Hazardous Air Pollutants (NESHAP);
- USEPA Asbestos Hazard Emergency Response Act (AHERA); and
- NYSDOL Code Rule 56.

12.3 Polychlorinated Biphenyls

PCBs are commonly found in electrical equipment that requires dielectric fluid such as transformers and capacitors, as well as hydraulic machinery, vacuum pumps, compressors, and heat exchanger fluids. PCBs have also been historically used in lighting ballasts and caulking.

For the purposes of this program, TRC will presume that all lighting ballasts contain over 50 parts per million (ppm) of PCBs, and all ballasts must be removed in 55-gallon drum(s) and recycled pursuant to 40

CFR 761.60-62. Even for ballasts labeled "No PCBs", as it has been determined by the USEPA that the potting material is be considered suspect as it has been found to contain greater than 50 ppm PCBs.

For potentially PCB-containing equipment other than ballasts (e.g., hydraulic oil, electric oil-filled switches, transformers, capacitors, etc.), representative samples will be collected to determine whether the fluids contain more than 50 ppm of PCBs. If PCBs are detected at a concentration of 50 ppm or greater, the materials will be classified as hazardous waste in New York State. Additionally, potential PCB containing wastes will be sampled in accordance with the USEPA Toxic substances Control Act (TSCA) (40 CFR Part 761). TRC will coordinate with NYSDEC to verify that equipment is de-energized prior to sampling.

In addition, representative samples of caulking material will be collected and tested to determine the concentration of PCBs. Each sample will be a representative sample of each distinct piece of equipment or caulk/glaze material. A minimum of three grab samples, formed to make one composite sample, will be collected from each homogeneous material and submitted for laboratory analysis of PCBs.

12.4 Universal Waste

40 CFR Part 273 and 6 NYCRR Section 374.3 establish requirements for managing universal wastes. Universal wastes are those that would reasonably be expected to be classified as hazardous wastes but, due to their universal use in industrial and residential properties, regulations were created to ensure that they are managed in a manner that prevents harm to the environment while reducing the regulatory burden on generators of these wastes.

Universal wastes include the following:

1. Batteries as described in 40 CFR Section 273.2
2. Pesticides as described in 40 CFR Section 273.3
3. Mercury containing equipment as described in 40 CFR Section 273.4 (e.g., electrical switches, lamps, manometers, regulators, and thermometers)
4. Lamps as described in 40 CFR Section 273.5

It is expected that pesticides will not be generated during building demolition. The characterization approach for mercury-containing equipment, lamps, and batteries are discussed below.

For the purposes of this program, TRC will assume that all mercury lamps, thermometers and electrical switches contain over 0.2 ppm TCLP mercury. These materials thus should be removed as universal waste in approved containers and disposed or recycled pursuant to universal waste regulations (40 CFR Part 273) at a regulated disposal facility. The USEPA issued a final rule, effective August 5, 2005, which adds mercury-containing equipment to the federal list of universal wastes regulated under the Resource Conservation and Recovery Act (RCRA) hazardous waste regulations. Per the universal waste regulations, analytical testing is not required.

13.0 STORAGE TANK ASSESSMENT

Area-specific requirements for tanks, facilities, water treatment, drainage structures, and other waste systems will follow provisions included in NYSDEC DER-10. The subsections below present area-specific requirements for each type of structure or system.

If storage tanks are present, an investigation of active and inactive bulk storage tanks and appurtenances, such as piping, dispensers, and fill ports will include the following structures and systems:

- Aboveground storage tanks (ASTs) over unpaved surfaces (i.e., soil or broken pavement in contact with the soil);
- ASTs over unbroken paved surfaces;
- Underground storage tanks (USTs) and distribution systems;
- Above-grade piping;
- Below-grade piping; and
- Loading and unloading areas.

13.1 ASTs and Distribution Systems

ASTs and distribution systems containing potential contaminants of concern will be evaluated to identify past and current releases. When ASTs are active, soil samples will be collected from the following AOCs for laboratory analysis of DER-required parameters and will meet the following criteria:

- Soil immediately adjacent to each AST or group of ASTs will be investigated and soil samples will be collected within five feet of the tank. The number, depth, and matrix of samples to be collected and submitted for laboratory analysis will be dependent on the tank capacity and/or length, in accordance with NYSDEC DER-10 Section 3.9.

13.2 USTs and Distribution Systems

USTs and distribution systems containing potential contaminants of concern will be evaluated to identify past and current releases. All permitted USTs must follow applicable federal, state, and local regulations, upgraded as necessary or closed in accordance with NYSDEC DER-10 Section 5.5. When USTs are active, soil samples will be collected from the following AOCs for laboratory analysis of DER-required parameters and will meet the following criteria:

- Soil immediately adjacent to each UST or group of USTs will be investigated and soil samples will be collected within five feet of the tank. The number, depth, and matrix of samples to be collected and submitted for laboratory analysis will be dependent on the tank capacity and/or length, in accordance with NYSDEC DER-10 Section 3.9.

- If the UST is located on bedrock, then a bedrock monitoring well will be installed.

13.3 Tank Piping

Above-grade piping will be evaluated only when there is evidence of past or present discharges (i.e. discolored or stained soil or surfaces).

Below-grade piping will be evaluated to identify past and current releases. The number and depth of soil samples to be collected and submitted for laboratory analysis will be dependent on the total piping in accordance with NYSDEC DER-10 Section 3.9.

14.0 STORMWATER ASSESSMENT

On occasion, a stormwater assessment will be required in order to remain compliant with a State Pollutant Discharge Elimination System (SPDES) permit. If necessary, the stormwater assessment will be completed per the TRC Stormwater Visual Examination and Sampling Guide, which is included in **Appendix A**.

15.0 FISH AND WILDLIFE RESOURCES IMPACT ANALYSIS

According to NYSDEC DER-10, the purpose of a Fish and Wildlife Resources Impact Analysis (FWRIA) is as follows:

- To identify potential or existing impacts to fish and wildlife resources from site contaminants of ecological concern via a Resource Characterization Study (RCS); and
- If the results of the RCS indicate that further assessment is needed, an Ecological Impact Assessment (EIA) is required to further define and evaluate the adverse impacts to fish and wildlife resources.

An FWRIA is not needed if one or more of the following criteria is met:

- The site remediation will be directed toward a specific discharge or spill event that does not adversely impact fish and wildlife resources;
- The site AOCs consist solely of USTs or underground discharge tank system, where no significant surface water and groundwater impacts have occurred;
- The site is a point source of contamination to groundwater (i.e., dry cleaner or gas station) which will be prevented from discharging to the surface water, there is no widespread soil contamination, and no existing habitat where endangered, threatened, or special concern species reside; or
- There are no fish, wildlife, or ecological resources present on or in the vicinity of the site.

If an FWRIA is required, it will be completed in accordance with the guidance provided in the NYSDEC Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (October 1994).

16.0 MANAGEMENT OF INVESTIGATION DERIVED WASTE

Investigation derived waste (IDW) is anticipated to include soil cuttings, well development and purge water, decontamination fluids, used personal protective equipment (PPE), and disposable sampling equipment and supplies. IDW will be managed in accordance with NYSDEC DER-10 paragraph 3.3(e)(1) and in consultation with the NYSDEC Project Manager.

To the extent feasible, soil cuttings will be returned to the boring, as prescribed in NYSDEC DER-10, unless grossly contaminated. Soil exhibiting evidence of gross contamination will be segregated and stored separately in steel 55-gallon drums or roll-off container for characterization and off-site treatment/disposal.

Well development and purge water will be containerized upon production. The water will be properly treated or disposed of, when any of the following are observed:

- Visual evidence of contamination, consisting of discoloration, sheens, free product or NAPL;
- Olfactory evidence of contamination; or
- Concentrations of contaminants above groundwater standards at levels of concern are known to be present in the monitoring wells, based on previous sampling of the groundwater.

If none of the above conditions are present, the containerized water will be recharged to the same groundwater unit within or directly adjacent to the source area in a manner that does not result in runoff. Water exhibiting evidence of contamination will be treated or disposed of at a permitted off-site facility or an existing on-site remedial facility designed to treat the water, if present.

Wash and rinse water used for equipment decontamination will be containerized in DOT-approved 55-gallon drums for off-site disposal.

Used PPE and disposable sampling equipment and supplies will be bagged as regular refuse and disposed as solid waste, unless grossly contaminated. Grossly contaminated material, if encountered, will be drummed separately.

Materials containerized for off-site disposal will be transported daily to a temporary storage area acceptable to NYSDEC and the property owner/operator. Containerized materials may be staged on pallets and will be clearly marked to indicate the contents of the containers, date of collection, and source of the material. TRC will oversee pickup and transport of IDW from the temporary storage area.

Appendix A
TRC Standard Operating Procedures

Table A-1: TRC SOPs within Appendix A

TRC Procedure / Program No.	SOP Title
Engineer Field Responsibilities	
RMD001	Field Activity Documentation for Environmental Investigations
RMD002	Chain-of-Custody Procedures
RMD005	Visual-Manual Procedure for Soil Description and Identification
RMD014	Headspace Field Screening Procedure
ECR010	Equipment Decontamination
ECR023	Packaging and Shipping of Non-Hazardous Environmental Samples
Monitoring Well Installation Procedures	
RMD007	Groundwater Monitoring Well Installation
ECR006	Well Development
ECR021	Well and Borehole Abandonment/Decommissioning
Potentiometric Surface Measurements and Soil/Water Sampling Procedures	
RMD008	Surface Water and Sediment Sampling
RMD011	Calibration of Field Instruments for Water Quality Parameters
ECR003	Soil Sampling
ECR004	Water Level and Product Measurements
ECR009	Groundwater Sampling
ECR016	Residential Well Sampling
Aquifer Testing Procedures	
ECR017	Hydrocarbon Baildown Test
ECR022	Pumping Tests
ECR029	Slug Test Procedures

Table A-1: TRC SOPs within Appendix A

TRC Procedure / Program No.	SOP Title
Soil Vapor Intrusion Procedures	
ECR015	Soil Vapor Point Installation and Active Vapor Sampling
ECR024	Indoor and Ambient Air Sampling
Vapor Pin®	Installation and Extraction of the Vapor Pin®
Other Applicable Procedures	
RMD012	Test Pit Investigations
BSI003	Asbestos Inspection Procedures
NA	Stormwater Visual Examination and Sampling Guide

Engineer Field Responsibilities

Title: **Field Activity Documentation for Environmental Investigations**		Procedure Number: **RMD 001**
		Revision Number: **0**
		Effective Date: **January 2013**
Authorization Signatures		
Terrance Hertz 1/25/2013	Elizabeth Denly 1/30/2013	
Technical Reviewer — Date Terrance Hertz	Remediation Practice Quality Coordinator — Date Elizabeth Denly	

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in the documentation of field activities for environmental investigations.

Field activity documentation is one of the most important activities that occur during field work. There is abundant information available for documenting the details of field work at the time the field work is taking place. It is critical that sufficient detail be documented during field work as it happens to allow others not present during the field activities to fully comprehend the field procedures and conditions at the time of the field work.

The objective of documenting field activities is to ensure that a collection of facts is recorded, the activities can be reconstructed from the documentation, and that the field activities are adequately logged in a manner that will be acceptable if the record is required as evidence in legal proceedings. An additional objective of adequately documenting field activities is to provide complete information that is useful and understandable to someone other than the note taker. Because the field books and field data forms provide the basis for future reports and analysis, facts and observations must be accurately recorded. Some regulatory agencies require that a copy of the field notes be included as part of the report submittal.

This SOP was not intended for use if computer tablets will be used. Consult with the Remediation Practice Quality Coordinator for procedures when tablets will be used.

1.2 Equipment

The following list is an example of items that may be utilized for field activity documentation. Project-specific conditions or requirements may warrant the use of additional items or deletion of items from this list.

- Field book(s) – bound book with water-resistant pages
- Indelible marking pens
- Field data forms – generic or project-specific
- Digital camera
- Pocket ruler
- GPS device

2.0 PROCEDURES

All entries must be legible and must be made in blue or black permanent ink, signed or initialed, and dated. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error.

The original entry should still be legible even though crossed out. Pages should never be removed from a field book.

2.1 Setup of Field Book and Logs

When multiple field personnel are on site, the Field Team Leader should decide the appropriate distribution of field books, field logs or project-specific forms necessary to document field activities. It is not necessary for each participant to take field notes.

1. Each field book assigned to a project should have the following information on the title page (the inside cover of the field book):

   - Project name
   - Site address
   - Site contact, if available
   - Project number(s)
   - TRC's name, address and phone number
   - Start and end dates of field book entries

2. Each field book may have a designated number (i.e., Book #1, Book #2, etc.) listed on the outside front cover.

3. Each field book will be a bound field survey book or notebook, water-resistant, and have sequentially numbered pages.

4. Other field books may or may not be required, dependent on the project needs, at the discretion of the Project Manager.

2.2 Documentation Requirements for Field Books or Daily Field Report Logs

Data collection activities performed during the field effort will be recorded in field books or on Daily Field Report Logs. Entries will be of adequate detail so that others will be able to comprehend a particular situation and it will be possible to reconstruct each activity without reliance on memory.

Entries into the field book or Daily Field Report Log may contain a variety of information. The terminology used in recording all field data should be objective, factual, and free of personal interpretation that may prove inappropriate. At the beginning of each daily entry, the date, start time, weather, and names of all field team members present will be entered. It is good practice to record the date on every page. The start and end of each day's entries in the field book or Daily Field Report Log will be signed or initialed and dated by the person(s) making the entry.

In general, it is expected that field notes will be collected every 15 minutes, as appropriate. Information included in the field book or Daily Field Report Log may include, but need not be limited to, the following:

- Chronology of activities, including entry and exit times;
- Names of all people involved in field activities and organizational affiliations;
- Level of personal protection used (if different from site-specific protocol/plan);

- Any changes made to site-specific protocol/plan
- Names of visitors to the site during field work and reason for their visit (unless in Daily Personnel Log)
- Sample location and identification
- Weather conditions, including temperature and any precipitation
- Day's objectives/scope of work
- Vehicle used (personal, rental) with travel time to site and mileage
- Measurement equipment identification (model/manufacturer) and calibration information
- Summary of equipment brought by subcontractor
- Communications while on site impacting site-specific protocol/plan
- Field screening results
- Site observations
- Sample collection methods and equipment
- Sample collection date (month/day/year) and time (military)
- Sample depths
- Whether grab or composite sample collected
- How sample composited, if applicable
- Sample description (color, odor, texture, etc.)
- Tests or analyses to be performed
- Sample preservation and storage conditions
- Equipment decontamination procedures
- QC sample collection
- Sample shipping methods, including tracking numbers, if applicable
- Unusual events or observations
- Record of photographs (unless in Photograph Log)
- Volume and type of investigation derived waste generated
- Sketches or diagrams
- Signature or initials of person recording the information

Upon receipt of the field book or Daily Field Report Log for a particular activity, the designated person recording the notes will begin recording notes on a new page. The person(s) recording the notes will sign/initial the new page and indicate the date, time, and weather conditions, prior to recording information about the field activity. The field book or Daily Field Report Log should indicate whether any Field Data Forms are being used. When the designated person recording the notes either relinquishes the field book or Daily Field Report Log to another team member or turns the book or log in at the end of the day, the person relinquishing the field book or Daily Field Report Log will affix a signature and date to the bottom of the last page used. If the page is not full, a diagonal line should be struck across the blank portion of the page. An example field book page is provided in Attachment A. An example Daily Field Report Log is provided in Attachment B.

Field data forms may be used to document sampling information for routine activities that have an associated form. A stockpile of blank forms will be kept in the field trailer/office or with the Field Team Leader. The field book or Daily Field Report Log should reference the form used during that event. Examples of TRC field data forms include:

- Sample log sheets (e.g., groundwater, sediment, soil gas, indoor air)
- Groundwater static water level data sheet
- Slug test data sheet

- Monitoring well construction summary/well development
- Monitoring well decommissioning
- Photograph log
- Soil boring/Rock core log
- Equipment log
- Calibration log

2.3 Documentation Requirements for Daily Personnel Logs

If applicable, the Daily Personnel Log will be maintained in the field trailer/office or by the Field Team Leader for the duration of the project to record the identities of all personnel who are on site. The following information will be recorded on Daily Personnel Logs:

- Names of field personnel
- Names of subcontractor personnel
- Names of visitors
- Affiliation of each person on site
- Date/time of entry and exit

2.4 Documentation Requirements for Photograph Logs

A field book/Daily Field Report Log entry or Photograph Log will be used to record the date and time of photographs taken at the project site. Digital cameras that imprint the date and time of the photograph may also be used to document conditions; however, prior to taking any site photographs with a digital camera, the photographer must verify the correct clock and calendar settings in the camera. An appropriate site figure may be used to note the location and direction of photographic documentation and should be referenced and attached to the log, if used. Examples of items that warrant photographic documentation include:

- General site topography
- Sampling and/or drilling locations
- Existing monitoring well locations
- Pre-existing property conditions and conditions following restoration
- Physical appearance of environmental samples
- Evidence of possible contamination
- Well casing or pad damage
- Rock cores

2.5 Documentation Requirements for Equipment Calibration Logs

A field book/Daily Field Report Log entry or Equipment Calibration Log will be completed to record appropriate information for the instruments calibrated each day. This information may include:

- Equipment manufacturer, model number and serial number
- Dates and times of calibration
- Supplies used (e.g., calibration gas)
- Individual who performed the calibration
- Adjustments made to the instrument during calibration

- Notes regarding the maintenance of the instrument

2.6 Documentation Requirements for Health and Safety Logs

A field book/Daily Field Report Log entry or Health and Safety Log will be completed to record Health and Safety issues during field activities. Entries may include:

- Daily health and safety meeting prior to performing work
- Any injuries, illnesses, near-misses, or the use of first aid supplies
- Activity under Level D conditions or the use of specific personal protective equipment (for Levels A, B or C only, if needed)
- Occurrence of possible work-related symptoms
- The date, name(s) of affected individuals and a description of the issue or incident and response
- A record of air monitoring results, any action level exceedances, and actions taken as the result of any action level exceedances

2.7 Documentation Requirements for Air Monitoring Logs

A field book/Daily Field Report Log entry or Air Monitoring Log will be completed to record monitoring results from real-time air monitoring instruments during field activities. The air monitoring devices will be located and operated in accordance with the Air Monitoring Plan. For hand-held instruments without data logging capabilities, readings will be recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. For instruments with data logging capabilities, the instruments will be periodically checked, with results recorded in the field book/Daily Field Report Log or on the Air Monitoring Log. Data will be downloaded at the end of each workday and maintained in the project files.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

The Field Team Leader has the responsibility to maintain the various logs, forms, and books that document daily field activities. Individual responsibilities may be delegated to other field staff, as appropriate.

Quality control procedures will place emphasis on the completeness and accuracy of all information recorded in the field and will be used to confirm that field notes contain statements that are legible, accurate, and comprehensive documentation of project activities. Field books/Daily Field Report Logs should be reviewed on a frequent basis by the Field Team Leader to confirm that:

- Field books/Daily Field Report Logs and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.

- Records are legible and in accordance with good record-keeping procedures, i.e., entries are signed or initialed and dated, data are not obliterated, and changes are initialed, dated, and explained.

- Sample collection, handling, preservation, and storage procedures were conducted in accordance with the protocols described in the project plans, and that any deviations were documented and approved by the appropriate personnel.

- Instruments were calibrated and operated in accordance with the procedures specified in the project plans.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation requirements for investigation-derived waste disposal with the Project Manager.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all field books/Daily Field Report Logs used during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

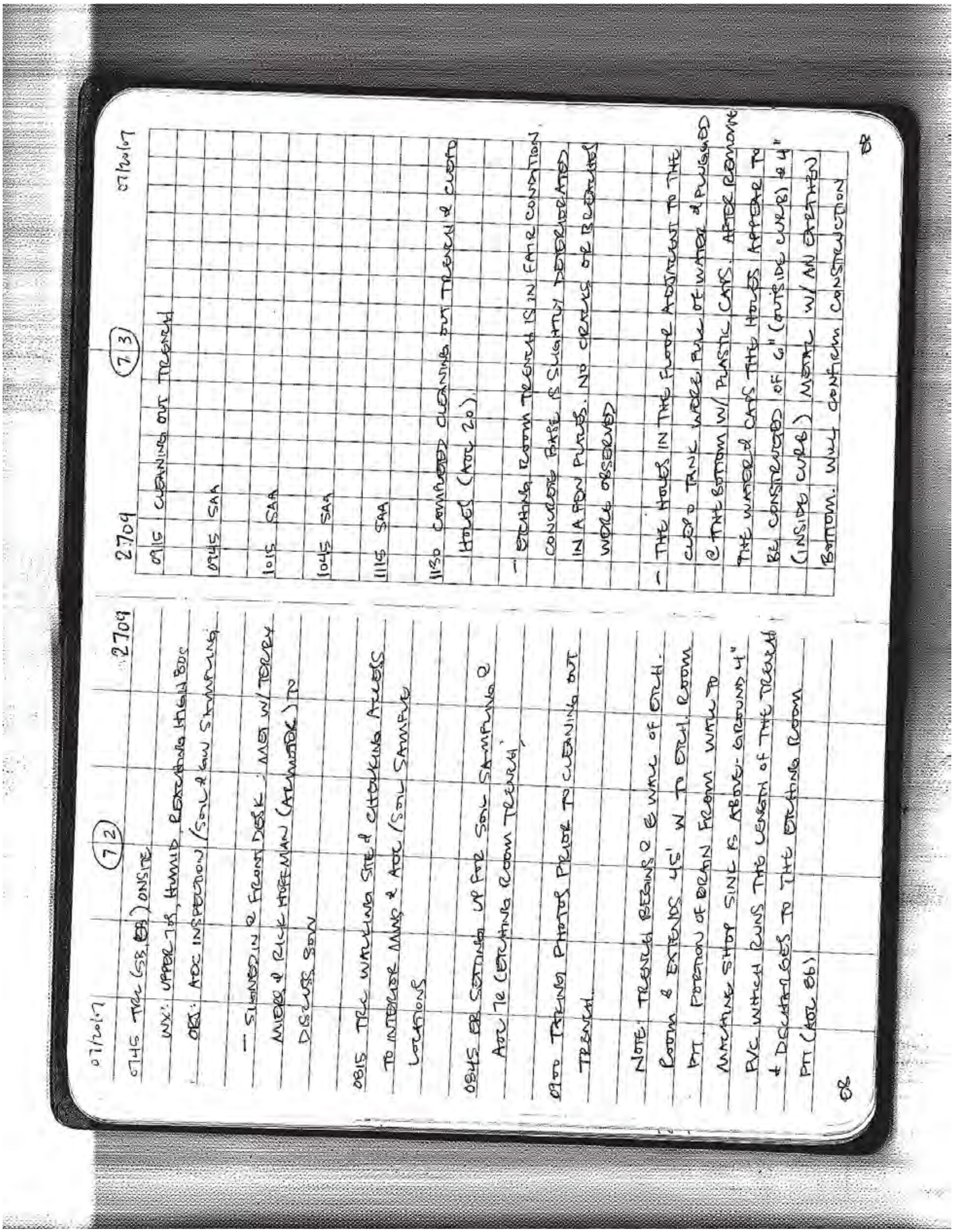
Completed standardized forms will be maintained by the Project Manager or Field Team Leader during the duration of the program and will be archived in the project files following completion of the field effort.

It is good practice to scan field notes and logs at the conclusion of field activities and store the resulting pdf files in the project directory.

6.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2013	NOT APPLICABLE

Attachment A: Example Page from Field Book


07/20/17 (72) 2709

0745 TRC (SB, EB) ONSITE
WX: UPPER 70s, HUMID, REACHING HIGH 80s
OBJ: AOC INSPECTION / SOIL & GW SAMPLING

- SIGNED IN @ FRONT DESK; MET W/ TERRY MIERS & RICK HOFFMAN (ARMSTRONG) TO DISCUSS SOW

0815 TRC WALKING SITE & CHECKING ACCESS TO INTERIOR AND & AOC / SOIL SAMPLE LOCATIONS

0845 EB SETTING UP FOR SOIL SAMPLING @ AOC 78 (ETCHING ROOM TRENCH)

0900 TAKING PHOTOS PRIOR TO CLEANING OUT TRENCH.

NOTE: TRENCH BEGINS @ E WALL OF ETCH. ROOM & EXTENDS 45' W TO ETCH. ROOM PIT. PORTION OF DRAIN FROM WALL TO MACHINE SHOP SINK IS ABOVE-GROUND 4" PVC WHICH RUNS THE LENGTH OF THE TRENCH & DISCHARGES TO THE ETCHING ROOM PIT (AOC 86)

EB

2709 (73) 07/20/17

0915 CLEANING OUT TRENCH

0945 SAA

1015 SAA

1045 SAA

1115 SAA

1130 COMPLETED CLEANING OUT TRENCH & CLOSED HOLES (AOC 20).

- ETCHING ROOM TRENCH IS IN FAIR CONDITION. CONCRETE BASE IS SLIGHTLY DETERIORATED IN A FEW PLACES. NO CRACKS OR BREACHES WERE OBSERVED

- THE HOLES IN THE FLOOR ADJACENT TO THE CLOSED TANK WERE FULL OF WATER & PLUGGED @ THE BOTTOM W/ PLASTIC CAPS. AFTER REMOVING THE WATER & CAPS THE HOLES APPEAR TO BE CONSTRUCTED OF 6" (OUTSIDE CURB) & 4" (INSIDE CURB) METAL W/ AN EARTHEN BOTTOM. WILL CONFIRM CONSTRUCTION

EB

Attachment B: Example Daily Field Report Log

DAILY FIELD REPORT LOG

CLIENT:	PROJECT :	DATE:
ADDRESS:		PROJECT #:
WEATHER:		PAGE: ______ OF ______
FIELD ACTIVITY:		

TIME	DESCRIPTION OF DAILY ACTIVITIES

THIS FIELD REPORT PROVIDES ONLY THE RESULTS OF OBSERVATIONS AND TESTS BY TRC PERSONNEL. THIS REPORT SHOULD NOT BE CONSTRUED AS SUPERVISION, DIRECTION, OR A RECOMMENDATION.

Prepared By: Date/Time:	TRC 123 Technology Drive Irvine, California 92618

Attachment C: SOP Fact Sheet

FIELD ACTIVITY DOCUMENTATION

PURPOSE AND OBJECTIVE

The objective of documenting field activities is to ensure that a collection of facts is recorded, the activities can be reconstructed from the documentation, and the field activities are adequately logged in a manner that will be acceptable if the record is required as evidence in legal proceedings. An additional objective of adequately documenting field activities is to provide complete information that is useful and understandable to someone other than the note taker. Facts and observations must be accurately recorded because the field books and field data forms provide the basis for future reports and analysis.

WHAT TO BRING

- Field book(s) – bound book with water-resistant pages
- Indelible marking pens
- Field data forms – generic or project-specific
- Digital camera
- Pocket ruler
- GPS device

OFFICE

- Ensure that there is adequate space for notes on the upcoming field event in the existing field book.
- If a new field book must be issued, note the field book number on the spine.
- A new field book should contain the following information on the inside cover: Project name; site address; site contact, if available; project number(s); TRC's name, address and phone number; and start and end dates of field book entries.
- Each field book may have a designated number (i.e., Book #1, Book #2, etc.) listed on the outside front cover.

ON-SITE

- Data collection activities will be recorded in field books. Entries will be of adequate detail so that individuals who were not onsite can reconstruct the day.
- The terminology used in recording all field data should be objective, factual, and free of personal interpretation.
- At the beginning of each daily entry, the date, start time, weather, and names of all field team members present will be entered.
- The start and end of each day's entries in the field book or Daily Field Report Log will be signed or initialed and dated by the person(s) making the entry.
- It is expected that field notes will generally be collected every 15 minutes. Information included in the field book may include, but need not be limited to, the following:
  - Names of all people involved in field activities;
  - Weather conditions;
  - Day's objectives/scope of work;
  - Vehicle used, travel time to site and mileage;
  - Equipment calibration information;
  - Summary of equipment brought by subcontractor;
  - Any changes made to site-specific protocol/plan;
  - Sample location and identification;
  - Communications while on site;
  - Field screening results;
  - Sample collection methods and equipment;
  - Sample collection date (month/day/year) and time (24-hour);
  - Sample depths;
  - Sample description (color, odor, texture, etc.);
  - Tests or analyses to be performed;
  - Sample preservation and storage conditions;
  - Unusual events or observations;
  - Volume and type of waste generated;
  - Sketches or diagrams.
- Upon receipt of the field book or Daily Field Report Log for a particular activity, the designated person recording the notes will begin recording notes on a new page.
- The person(s) recording the notes will sign/initial the new page and indicate the date, time, and weather conditions, prior to recording information about the field activity.
- The field book or Daily Field Report Log should indicate whether any Field Data Forms are being used.
- Additional logs such as photo logs, health and safety logs or equipment logs may be required depending on the site requirements.

1

FIELD ACTIVITY DOCUMENTATION

DOS AND DO NOTS OF FIELD ACTIVITY DOCUMENTATION

DOs:

- DO have the following items when going into the field: Field Book and an indelible marking pen (i.e. ball-point pen) ONLY; field forms; contact phone numbers; business cards.
- DO review all available figures and workplans.
- DO take note of any atypical conditions at the site.
- DO call the Project Manager or Field Team Leader if unexpected conditions are encountered or at least twice during the work day to update them. It is also recommended to call when activities are winding down for the day to make sure that the workplan has been fully implemented and there are no additional tasks to complete.
- DO have the numbers for contractors, vehicle and equipment rental providers and utility companies readily available while in the field.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if there are any concerns.
- DO NOT use markers to label samples or record field notes.

Title: **Chain-of-Custody Procedures**		Procedure Number: **RMD 002**
		Revision Number: **0**
		Effective Date: **March 2013**

Authorization Signatures

03/01/2013	03/01/2013
Technical Review Date James Peronto	Remediation Practice Quality Coordinator Date Elizabeth Denly

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FIGURES

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in proper Chain-of-Custody practices.

This SOP was prepared to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. Sample custody procedures are an important part of the field investigation program in order to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law or other evidentiary venue. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration (i.e., representative of the identified sample media).

1.2 Summary of Method

Evidence of the sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be properly documented.

A sample or evidence file is considered to be in a person's custody if the item is:

- In a person's possession
- In the view of the person after being in a person's possession
- Secured and preserved so that no one can tamper with it after having been in a person's possession
- In a secured area, restricted to authorized personnel

The Field Team Leader or designee is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The Field Team Leader or designee is also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

1.3 Equipment

The following list is an example of items that may be utilized when implementing sample custody procedures in the field. Project-specific conditions or requirements may warrant the use of additional items or deletion of items from this list. Many of these items may be provided by the selected analytical laboratory for a given project.

- Chain-of-Custody forms
- Sample labels
- Sample tags
- Custody seals
- Computer
- Indelible/waterproof ink
- Printer

2.0 PROCEDURES

Sample custody and transfer procedures are summarized below. These procedures are intended to ensure that the samples will arrive at the laboratory with the Chain-of-Custody intact. The Chain-of-Custody procedures are initiated in the field immediately following sample collection. The procedures consist of four main components: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the Chain-of-Custody (COC) form, (3) reviewing the COC form for accuracy and (4) preparing the samples for shipment and transfer of custody.

2.1 Specific Chain-of-Custody Procedures

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container. Individual sample containers may be pre-labeled or labeled in the field at the time of collection. Sufficient sample information should be cross-referenced in the field documentation for tracking purposes.

Sample labels typically contain the following information:

- Unique sample identification
- Sample location and/or depth/description number, if different from above
- Sample matrix
- Type of analysis to be performed
- Type of chemical preservation used
- Grab or composite designation
- Filtered or unfiltered
- Sampling date and time
- Sampler's affiliation and initials
- Site and/or client name

An example of a sample label is provided in Figure 1.

2.1.2 Custody Seals

Custody seals may be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. Custody seals are attached to the cover seal of the cooler and can be covered with clear plastic tape after being signed and dated by field personnel. An example of a custody seal is shown in Figure 1. The use of custody seals will be determined on a project-specific basis by the Project Manager.

2.1.3 Chain-of-Custody Form

For all analyses, COC forms must be completed for each sample set submitted. COC forms are initiated by the samplers in the field and maintained until samples are analyzed by the laboratory. If multiple laboratories are being used, a separate set of COC forms must be completed for each laboratory receiving samples to ensure proper transfer of custody from the time of sample collection to analysis. These forms serve as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms typically contain the following pertinent information:

- Project/site name and/or project number
- Carrier name, if applicable
- Air bill numbers(s), if known and applicable
- Laboratory name and address
- Sample identifications
- Sample matrix (e.g., soil, water)
- Type of sample (i.e., grab or composite)
- Date/time sample collected
- Size, type, and number of containers
- Preservative used
- Required analysis or method
- Turnaround time
- Names of individuals responsible for custody of samples
- Date shipped or otherwise transferred

Figure 2 provides an example COC form. It should be noted that this is an example format only. Laboratories typically provide their own laboratory-specific COC form. Other COC formats may be used as long as all of the applicable information is included. COC forms will be initiated in the field.

All entries on the COC form must be legible and must be made in blue or black permanent ink. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error. The original entry should still be legible even though crossed out.

2.1.4 Transfer of Custody

Samples will be accompanied by a properly completed COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time of transfer on the COC form.

All samples will be shipped directly to the laboratories by a TRC employee, an overnight commercial carrier, or a laboratory-supplied courier service.

In the case of sample shipment by an overnight commercial carrier, a properly prepared air bill, including the project number (Figure 3), will serve as an extension of the COC form while the samples are in transit. The COC forms will be sealed inside the sample cooler within a clear plastic bag and the custody seals, if used, will be completed on the outside of the cooler prior to shipment. Commercial carriers are not required to sign off on the custody forms since the forms are sealed inside the cooler prior to shipment so any custody seal remains intact. The original COC form will accompany the samples at all times. A copy of all COC forms submitted to the laboratory will be retained by the sampler along with field records/logbooks documenting sample collection and will be placed in the project files.

If at the completion of sampling the samples are not shipped directly from the field or point of collection to the analytical laboratory, the samples will be temporarily stored in an iced cooler at a secure location (e.g., locked vehicle, residence, office) or in a locked refrigerator at the TRC office. Access to the secure location and transfer of the sample containers for laboratory delivery shall only be provided by a TRC employee and such sample transfer shall be recorded on the COC form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Following sample collection, all samples will be brought to a location for batching and paperwork checks. At this location, labels and logbook information are cross-checked to ensure there is no error in sample identification or sample collection time and that all samples are accounted for. The sample information is transferred to the COC form. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled for transport.

The Field Team Leader has the responsibility of maintaining the COC and air bill documentation. Individual responsibilities may be delegated to other field staff, as appropriate. Quality control procedures will place emphasis on ensuring that appropriate samples were collected and submitted to the laboratory for the correct analyses. The COC forms will also be reviewed by the Field Team Leader or designee to ensure that all required information is clearly presented.

Many laboratories will provide a sample receipt confirmation via electronic mail upon request. COC forms should be cross-checked with laboratory sample receipt confirmations, if applicable, to ensure that all samples were received and logged-in correctly by the laboratory.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Not applicable.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all COC forms completed during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

It is good practice to scan all completed COC forms at the conclusion of field activities and store the resulting electronic PDF files in the project directory.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001. December 1987.

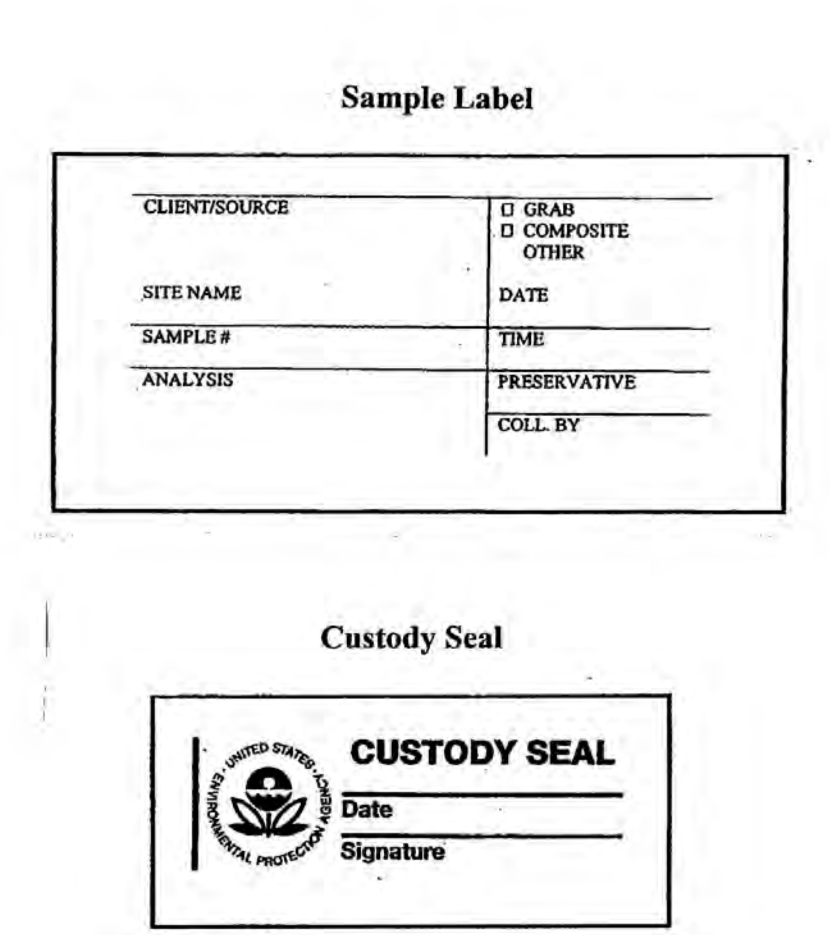
U.S. Environmental Protection Agency (EPA) Office of Enforcement and Compliance Monitoring – National Enforcement Investigations Center (NEIC) requirements (NEIC, 1986)

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	MARCH 2013	NOT APPLICABLE

Figure 1 Example Sample Label and Custody Seal

Example Custody Seal



Sample Label

CLIENT/SOURCE	☐ GRAB ☐ COMPOSITE OTHER
SITE NAME	DATE
SAMPLE #	TIME
ANALYSIS	PRESERVATIVE
	COLL. BY

Custody Seal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL

Date

Signature

Figure 2 Example Chain-of-Custody Form

TRC
Customer-Focused Solutions

Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Chain-of-Custody Record

Page ____ of ____

Project Name ______________________
Project No.: ______________________
Sampling Date(s): ______________________
Laboratory Name: ______________________
Laboratory Location: ______________________
Sampler Name(s): ______________________
____

Shipping Carrier ❑ FED EX ❑ COURIER
Date Shipped ______________________
Airbill No. ______________________

MCP Work Only: Have the appropriate number of field samples been collected for this program?
❑ YES ❑ NO

Turnaround Time (Circle One)
15 Day 10 Day 5 Day 3 Day Other: ________

ANALYSIS AND PRESERVATIVE

SAMPLE ID	DATE/TIME SAMPLED	COMPOSITE OR GRAB	MATRIX	VOLUME / CONTAINER TYPES	NUMBER OF CONTAINERS							
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								

COMMENTS

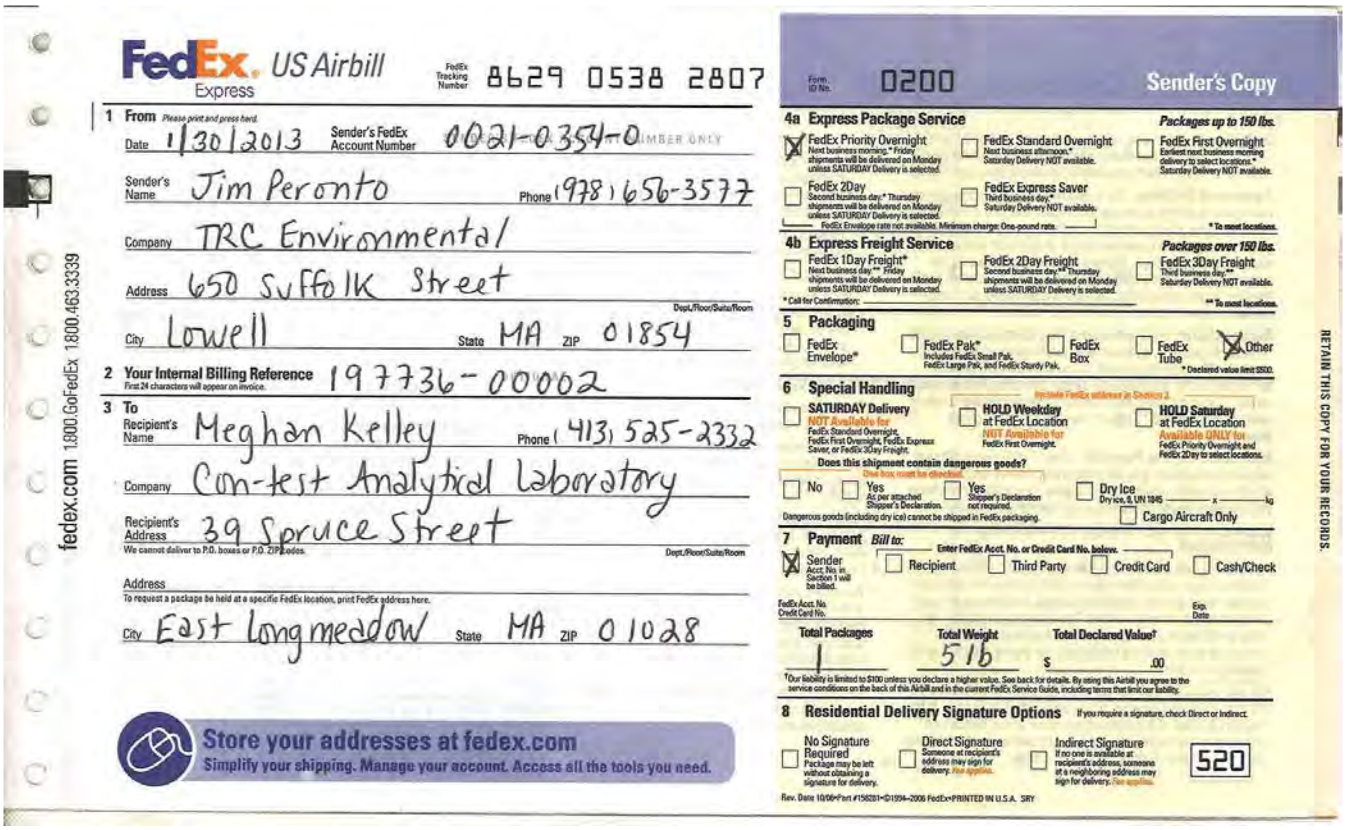
Send results to: ______________________
Cooler temperature: ______________________

Relinquished By:(Signature)	/ Date/Time	Received By:(Signature)	/ Date/Time
Relinquished By:(Signature)	/ Date/Time	Received By:(Signature)	/ Date/Time

№ 0020

WHITE – LABORATORY YELLOW – LABORATORY COPY PINK – OFFICE COPY GOLD – FIELD COPY

Figure 3 **Example Federal Express Air Bill**



FedEx Express US Airbill
FedEx Tracking Number 8629 0538 2807
Form ID No. 0200 Sender's Copy

1 From Please print and press hard.
Date 1/30/2013 Sender's FedEx Account Number 0021-0354-0
Sender's Name Jim Peronto Phone (978) 656-3577
Company TRC Environmental
Address 650 Suffolk Street Dept./Floor/Suite/Room
City Lowell State MA ZIP 01854

2 Your Internal Billing Reference 197736-00002
First 24 characters will appear on invoice.

3 To
Recipient's Name Meghan Kelley Phone (413) 525-2332
Company Con-test Analytical Laboratory
Recipient's Address 39 Spruce Street
We cannot deliver to P.O. boxes or P.O. ZIP codes. Dept./Floor/Suite/Room
Address
To request a package be held at a specific FedEx location, print FedEx address here.
City East Longmeadow State MA ZIP 01028

Store your addresses at fedex.com
Simplify your shipping. Manage your account. Access all the tools you need.

4a Express Package Service — Packages up to 150 lbs.
[X] FedEx Priority Overnight
[ ] FedEx Standard Overnight
[ ] FedEx First Overnight
[ ] FedEx 2Day
[ ] FedEx Express Saver

4b Express Freight Service — Packages over 150 lbs.
[ ] FedEx 1Day Freight
[ ] FedEx 2Day Freight
[ ] FedEx 3Day Freight

5 Packaging
[ ] FedEx Envelope
[ ] FedEx Pak
[ ] FedEx Box
[ ] FedEx Tube
[X] Other

6 Special Handling
[ ] SATURDAY Delivery
[ ] HOLD Weekday at FedEx Location
[ ] HOLD Saturday at FedEx Location
Does this shipment contain dangerous goods?
[ ] No [ ] Yes As per attached Shipper's Declaration [ ] Yes Shipper's Declaration not required [ ] Dry Ice
[ ] Cargo Aircraft Only

7 Payment Bill to:
[X] Sender [ ] Recipient [ ] Third Party [ ] Credit Card [ ] Cash/Check

Total Packages 1 Total Weight 5 lb Total Declared Value $ .00

8 Residential Delivery Signature Options
[ ] No Signature Required [ ] Direct Signature [ ] Indirect Signature

520

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Attachment A: SOP Fact Sheet

CHAIN-OF-CUSTODY PROCEDURES

PURPOSE AND OBJECTIVE

Chain-of-Custody procedures have been developed to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Sample custody procedures are an important part of the field investigation program to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

WHAT TO BRING

- Chain-of-Custody (COC) forms
- Sample Labels
- Custody Seals (if required)
- Indelible/waterproof ink

ON-SITE

- Complete all sample labels with indelible/waterproof ink.
- At a minimum, sample labels should include: site name; unique sample identification; sample date and time.
- COC forms must be completed for each sample set and must be initiated in the field by the sampler.
- COC forms must be completed in blue or black permanent ink.
- At a minimum, the COC forms should include: site name; sample identification; sample matrix; type of preservative; type of analysis; sampling date; and sampler's name.
- Once sampling activity is completed and the COC form is filled out, place samples in sample coolers.
- Package samples to prevent breakage and/or leakage.
- The COC forms will be reviewed by the Field Team Leader or designee prior to relinquishing the samples.
- The original COC form must accompany samples to the laboratory.
- When samples are transferred from one person to another, both the relinquisher and the person receiving the samples should sign, date and record the date of transfer on the COC form.
- If samples are not sent directly to laboratory, samples need to remain on ice and be stored in a secure location.

Title: **Visual-Manual Procedure for Soil Description and Identification**	Procedure Number: **RMD 005**
	Revision Number: **0**
	Effective Date: **September 2013**

Authorization Signatures			
Marc C Flanagan		Elizabeth Denly	
Technical Reviewer Marc Flanagan	Date 09-26-13	Remediation Practice Quality Coordinator Elizabeth Denly	Date 9/26/13

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Page No.

ATTACHMENTS

Attachment A	Field Forms
Attachment B	USCS Field Reference Sheets
Attachment C	SOP Fact Sheet

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the method for identifying and describing soil samples in soil borings, test pits, and soil grab samples. The SOP was prepared in general conformance with American Society for Testing and Materials (ASTM) Standard D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)* and other pertinent technical publications.

1.2 Summary of Method

The objective of this method is to standardize the collection and documentation of information on soil that is useful for the purpose of hydrogeological or geotechnical evaluation of a site. The use of standardized visual examination and manual test methods by all field personnel results in standardized data that can be evaluated later for geologic and engineering uses. Consistent soil description is important because during many projects multiple employees may be involved at different times. Hence, being able to compare or correlate soil classification logs that were created by different geologists is essential for creating consistent subsurface interpretations. The methods outlined in this SOP can be utilized for the characterization of soils in the field, field office, or other setting. Characterization of the soils in a relatively undisturbed state is preferred, but is subject to the limitations of the collection methods utilized.

Soil samples may be collected by various means, as discussed in TRC's Soil Sampling SOP. Regardless of the sample collection method, the resulting soil sample should be visually described and characterized. Visual examination of the sample will result in identifying grain size, particle size percentages, geologic and geotechnical modifiers and/or classifications, and a host of secondary characteristics. Manual and laboratory test methods also may be utilized to provide additional characteristics of the material, aiding in the description of fine-grained soils and providing more detailed geotechnical characterization.

The data gathered from the visual observations and manual test results are then recorded following an industry recognized classification system in a field log.

1.3 Equipment

The following list of equipment may be utilized when identifying and describing soil samples. Site-specific conditions may warrant the use of additional items or deletion of items from this list.

- Appropriate level of personal protection
- Field book, boring logs, test pit logs (as applicable)
- A copy of boring logs or field notes from previous work performed at or near the site
- Pocket penetrometer or miniature vane shear device
- Munsell Soil Color Chart
- Burmister and/or Unified Soil Classification System (USCS) classification chart/reference sheets
- Sand grading chart
- Appropriate knife

- Spoon and/or small spatula
- Tape measure, folding ruler or yard stick
- Portable table
- Polyethylene sheeting
- Hand lens
- Deionized water in squeeze bottle
- Small squirt bottle with dilute hydrochloric acid (1 part 10N HC1 to 3 parts water)

1.4 Definitions

Not Applicable; terms defined throughout SOP.

1.5 Health & Safety Considerations

TRC personnel may be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific health and safety plan (HASP). TRC personnel will use the appropriate level of personal protective equipment (PPE) as defined in the HASP.

1.6 Cautions and Potential Problems

- Samples collected for identification and description may contain hazardous substances or petroleum hydrocarbons. Consult the site-specific HASP for air monitoring and PPE requirements.

- One of the most common problems encountered when identifying soil types is the misidentification of fine-grained soils. If new to the identification process, take time to perform the manual field tests presented herein and/or consult with an experienced geologist or engineer.

- Geologic and engineering principles are both utilized in this method. Remember a well or widely graded soil (engineering term) is a poorly sorted soil (geologic term).

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Workers (HAZWOPER)
- 8-hour annual refresher training

2.0 PROCEDURES

This SOP includes procedures for both the modified Burmister and USCS soil classification systems. Consult the Project Manager and site work plan for guidance on the appropriate system. Several components of the soil description overlap between the two methods; however, there are some slight differences, such as the descriptors for percent composition (e.g., Burmister: "some" means 20-35% and USCS: "some" means 30-45%). Again, consistent soil description is important because during many projects multiple employees may be involved in performing field work. Hence, being able to compare between logs that were created by different geologists is essential for creating subsurface interpretations.

2.1 Modified Burmister Soil Classification System

The general description of a soil sample should be in the following order:

1. Color
2. Major Constituent – capitalized
3. Minor Constituent(s)
4. Geologic modifiers or classifications (e.g., glacial deposit, fill material) in parentheses
5. Density
6. Moisture content
7. Modifiers for fine fraction of sample (plasticity, dilatancy and toughness)
8. Other significant observations (e.g., odors, staining, sheen, petroleum product, debris)

Use the following guidelines when recording soil descriptions:

- If the major constituent comprises more than 50% of the soil, then fully capitalize the major component descriptor (e.g., SAND);
- If the major constituent comprises less than 50% of the soil, capitalize the descriptor (e.g., Sand);
- Place a comma after the major and minor constituent descriptors;
- Place size qualifiers such as coarse, medium, or fine before the major constituent descriptors (see Section 2.7);
- Use the appropriate adjectives for proportions in Section 2.3.2 (e.g., and, some, little, trace) when describing the minor fraction(s); and
- Use the modifiers for fine grained soils described in Section 2.8.

EXAMPLES:
Tan, medium SAND, little fine sand, trace coarse sand, trace silt, statified (Outwash), loose, wet.

Or

Gray, CLAY, soft, wet, medium plasticity, no dilatancy and low toughness.

When logging a soil sample collected from a boring (e.g., split spoon or acetate liner) where more than one soil type is present, describe each one separately, using additional line(s) on the boring log form. Start the description from the top and log each change in stratigraphy in sequence to the bottom. Record the length (e.g., 0-0.5 ft.) at the beginning of each separate sequence description, followed by a colon. Draw a line below the bottom of the complete sample description.

2.2 USCS Soil Classification System

The USCS is based on grain size and response to physical manipulation at various water contents. This system is often used for classifying soils encountered in boreholes, test pits, and surface sampling. The following properties form the basis of USCS soil classification:

- Percentage of gravel, sand, and fines;
- Shape of the grain size distribution curve; and
- Plasticity and compressibility characteristics.

Four soil fractions are recognized: cobbles, gravel, sand, and fines (silt or clay). The soils are divided as coarse-grained soils, fine-grained soils, and highly organic soils. The coarse grained soils contain 50 percent of grains coarser than a number 200 sieve (approximately 0.08 mm). Fine grained soils contain more than 50 percent of material smaller than the number 200 sieve. Organic soils contain a significant percentage of organic material (leaves, roots, peat, *etc*. in various stages of decomposition). Soil description should be concise and stress major constituents and characteristics for fine-grained, organic, or coarse-grained soils.

The general description of a soil sample should be in the following order:

1. Group Name (Group Symbol)
2. Percent and Range of Particle Sizes
3. Plasticity
4. Color (Munsell Color Chart)
5. Odor
6. Moisture
7. Density
8. Additional Comments
9. Geological Origin (Stratigraphic Unit)

EXAMPLES:
Well Graded Gravel with Sand (GW): mostly fine to coarse subangular gravel, little fine to coarse subangular sand, yellowish brown (10YR 5/4), no odor, moist, loose, few small cinders, fill.

Or

Silt (ML): mostly silt, nonplastic, gray (7.5YR 5/1), slight hydrocarbon odor, moist, medium dense, lacustrine.

2.2.1 Group Name (Group Symbol)

The USCS recognizes 15 soil groups and uses names and letter symbols to distinguish between these groups. The coarse grained soils are subdivided into gravels (G) and sands (S). Both the gravel and sand groups are divided into four secondary groups. Fine grained soils are subdivided into silts (M) and clays (C). Soils are also classified according to their plasticity and grading. Plastic soils are able to change shape under the influence of applied stress and to retain the shape once the stress is removed. Soils are referred to either low (L) or high (H) plasticity. The grading of a soil sample refers to the particle size distribution of the sample. A well graded (W) sand or gravel has a wide range of particle sizes and substantial amounts of particles sized between the coarsest and finest grains. A poorly graded (P) sand or gravel consists predominately of one size or has a wide range of sizes with some intermediate sizes missing.

The flow charts included in Attachment B: USCS Field Reference Sheets, for fine- and coarse-grained soils, can be used to assign the appropriate group symbol(s) and name and are replicated from ASTM Standard D2488. If the soil has properties which do not distinctly place it into a specific group, borderline symbols (e.g., SP-SM, GP-GC, etc.) may be used.

Soils which have characteristics of two groups are given boundary classifications using the names that most nearly describe the soil. The two groups are separated by a slash. The same is true when a soil could be well or poorly graded. Again the two groups are separated by a slash.

2.3 Soil Identification Based on Grain Size

2.3.1 Grain-Size Scales

Determination of grain size can be difficult, especially for the fine grained particles. Identification of coarse grained particles can be aided by grain size particle charts with actual samples affixed to the card. In general, fine grained particles are not visible with the naked eye or a hand lens and require manual field tests to differentiate between silts and clays.

Peat, organic material in various stages of decomposition, usually appears dark brown to black, has a fibrous to amorphous texture, with an organic odor. This material should be classified as highly organic soil (Peat; Hummus; or Swamp/bog deposit). This material is not subject to grain size classification described herein.

Grain size classification should be based on the following method.

COARSE GRAINED PARTICLES

- **Boulder:** > 300 mm (>12 in.)
- **Cobble:** 75 - 300 mm (3 in. – 12 in.)
- **Coarse Gravel:** 19 - 75 mm (¾ in. – 3 in.)
- **Fine Gravel:** 4.75 - 19 mm (No. 4 sieve – ¾ in.)
- **Coarse Sand:** 2.0 - 4.75 mm (No. 10 sieve – No. 4 sieve)
- **Medium Sand:** 0.425 - 2.0 mm (No. 40 sieve – No. 10 sieve)
- **Fine Sand:** 0.075 - 0.425 mm (No. 200 sieve – No. 40 sieve)

FINE GRAINED PARTICLES

Note that these particle sizes cannot be visually differentiated with standard field equipment. Silts and clays are distinguished in the field by cohesion and plasticity.

Burmister:
- **Silt:** 0.002 - 0.075 mm
- **Clay:** <0.002 mm

USCS:
- **Silt & Clay:** <0.075 mm (< No. 200 sieve)

2.3.2 Proportions

Proportions of grain sizes need to be described in accordance with one of the two following classification systems. Note that in either system minor constituents also include ancillary materials such as mica flakes, dark minerals, naturally occurring organic matter, or anthropogenic material (e.g., fill, brick, concrete).

Modified Burmister:
For geologic description, proportions of grain sizes will be based upon the following nomenclature:

- **Trace:** 0-10%
- **Little:** 10-20%
- **Some:** 20-35%
- **And:** 35-50%

The major soil sample constituent is always capitalized and listed first.

USCS:
For geologic description, proportions of grain sizes will be based upon the following nomenclature:

- **Trace:** < 5%
- **Few:** 5-10%
- **Little:** 15-25%
- **Some:** 30-45%
- **Mostly:** > 50%

The soil is *fine grained* if it contains 50% or more fines (<0.075 mm or passes #200 sieve)

The soil is *coarse grained* if it contains less than 50% fines.

2.4 Color

The main color value should be stated, along with a modifier, if appropriate. For example:

- light brown
- dark brown
- reddish brown
- brown

The presence of mottling (patches or spots of differing colors) should be included in the description, where present. For example:

Gray, poorly sorted angular fine to medium SAND, some silt, trace angular coarse sand, trace clay (lodgement glacial till), slightly mottled, dense, moist (Modified Burmister description)

Or

Well Graded Sand (SW), mostly angular fine to medium sand, little to some silt, few angular coarse sand, few clay, gray, no odor, moist, dense, lodgement glacial till. (USCS description)

As with other components of soil classification, consistent soil color descriptions can be very helpful when preparing subsurface interpretations from soil data collected by different personnel. To that end, the use of Munsell Soil Color charts may be implemented to standardize color nomenclature. Just as paint stores have pages of color chips, soil scientists use a book of color chips that follow the Munsell System of Color Notation. The system has three components: Hue (a specific color), Value (lightness and darkness) and Chroma (color intensity). For example, a brown soil may be noted as: hue value/chroma (10YR 5/3).

2.5 Relative Density

The modifiers used to describe soil relative density depend on whether the soil is cohesive (e.g., clay) or granular/non-cohesive (gravel, sand or silt). Field evaluation of the density of non-cohesive soils is based the ease of penetration by the sampling equipment used. The density of cohesive soils is based the compressive soil strength of soil or soil stiffness (i.e., how much the soil compresses under a given pressure). Density can be directly measured in the field, such as with the ASTM Standard D1586: Standard Penetration Test during split spoon sample collection or with a pocket penetrometer. Alternatively, the density can be measured qualitatively, such as the ease of thumb penetration. Methods of determining density and the appropriate density modifiers are discussed in the following sections.

2.5.1 Soil Samples Collected with Split Spoons

During soil sample collection using split spoons, the density can be based on the N-Value, which is the sum of the middle two 6-inch blow counts of a two foot split spoon or the last two 6-inch blow counts of an 18-inch split spoon (ASTM Standard D1586: Standard Penetration Test). Professional judgment should be used when applying the density modifier. If high blow counts are due to the presence of a cobble, boulder or large piece of gravel that impedes forward progress of the split spoon, density should be based upon the character of the material in the split spoon, if any, or omitted from the description. A notation should be made in the sample description when this situation occurs. Appropriate modifiers are described in the following table:

<table>
<tr><th colspan="2">Non-Cohesive (Granular Soils)</th><th colspan="2">Cohesive Soils</th></tr>
<tr><th>N-Value (Blows/ft)</th><th>Density</th><th>N-Value (Blows/ft)</th><th>Density</th></tr>
<tr><td>0-4</td><td>very loose</td><td><2</td><td>very soft</td></tr>
<tr><td>4-10</td><td>loose</td><td>2-4</td><td>soft</td></tr>
<tr><td>10-30</td><td>medium dense</td><td>4-8</td><td>medium</td></tr>
<tr><td>30-50</td><td>dense</td><td>8-15</td><td>stiff</td></tr>
<tr><td rowspan="2">>50</td><td rowspan="2">very dense</td><td>15-30</td><td>very stiff</td></tr>
<tr><td>>30</td><td>hard</td></tr>
</table>

2.5.2 Test Pit Samples

In test pits, density is subjective and should be based upon the ease of excavation. The above modifiers in Section 2.5.1 for granular and cohesive soils should be used in the description. The following should be used as a guide for test pits:

- **Very Loose/Very Soft –** The bucket of the excavating equipment easily penetrates the soil and fills in one pass.
- **Medium Dense/Medium –** Several passes are required to fill the bucket.
- **Very Dense/Very Stiff –** The bucket has difficulty penetrating the soil.

2.5.3 Soil Samples Collected Via Direct Push Technology

In borings advanced by direct push methods, field evaluation of density is more subjective. Blow counts along with visible qualifiers such as number of passes to fill an excavation bucket are not applicable to direct push methods. Samplers therefore need to pay attention to the progress of the sampling tool being advanced, as well as gather information from the driller advancing the tool. Driller's input is very valuable as the macro core might be advanced at varying speeds to best achieve the goal of the boring. Below are approximations for estimating soil densities while utilizing direct push methods:

- **Very Loose/Very Soft** – Macro core advances easily, penetrates within a few seconds.
- **Medium Dense/Medium** – Macro core advances slowly but steadily, penetrates within a minute or two.
- **Very Dense/Very Stiff** – Macro core advances very slowly if at all, penetration may take several minutes.

Granular Soils	Cohesive Soils	Thumb Penetration Key
very loose	very soft	very easily – inches
loose	soft	easily – inches
medium dense	medium	moderate effort – inches
dense	stiff	indented easily
very dense	very stiff	indented by nail
	hard	difficult by nail

Similar to above, if drilling progress is slowed due to the presence of a cobble, boulder or large piece of gravel that impedes forward progress of the direct push sampler, density should be based upon the character of the material in the sampler, if any, or omitted from the description. A notation should be made in the sample description when this situation occurs.

2.5.4 Pocket Penetrometer

A pocket penetrometer is a field tool which can be implemented to directly measure compressive soil strength. The unit is spring-operated, and it is measures strength in tons/sq. ft. (tsf) or kg/sq. cm by pushing a loading piston into soil until the calibration mark is level with soil. Compressive load is indicated by reading a scale on the piston barrel. A friction ring indicates maximum reading. The reading correlates to the density description as follows:

Cohesive Soils	Compressive Strength (tsf)
very soft	< 0.25
soft	0.25 – 0.50
medium	0.50 – 1.0
stiff	1.0 – 2.0
very stiff	2.0 – 4.0
hard	> 4.0

The user should refer to the pocket penetrometer instruction manual for specifics on operation. It is recommended that several pocket penetrometer readings be collected for each soil horizon and averaged to determine the density, as opposed to one single reading.

A miniature vane shear device can also be used to directly measure compressive soil strength of cohesive soils. The device is a spring-operated torsional test that provides shear strength by measuring the resistance of turning a vane inserted into the sample.

2.6 Moisture Content

Moisture content should be described using the following modifiers:

- **Dry** – no apparent moisture, dusty.
- **Moist** – slight moisture content but no visible water, soils may stick together.
- **Wet** – water dripping from sample; usually soil is below the water table.

2.7 Geologic Modifiers or Classifications

Sedimentological descriptions aid in the geologic classification of a soil material. Only insert geologic modifiers when present.

2.7.1 Stratification

The presence of alternating layers of non-cohesive materials of different grain sizes or color with layers ***at least 6 mm*** thick. Note thickness of layers.

2.7.2 Lamination or Varves

The presence of alternating very thin layers of fine materials or color, such as silt and clay, with layers ***less than 6 mm*** thick. Note thickness of layers.

2.7.3 Sorting

A geological term used to describe how close in size the grains in a sample are to each other. For example, a *well sorted* sample contains grains of similar size; a *poorly sorted* sample contains grains of many sizes. **Caution:** Sorting and grading both describe grain size distribution and can easily be confused (e.g., well sorted is the opposite of well graded). If possible, either sorting or grading terminology, NOT both, should be used for a given project.

2.7.4 Grading

An engineering term used to describe the range in grain sizes present in a sample. For example, a *narrowly graded* or *poorly graded* sample contains grains of similar size; a *widely graded* or *well graded* sample contains grains of many different sizes. **Caution:** Sorting and grading both describe grain size distribution and can easily be confused (e.g., well sorted is the opposite of well graded). If possible, either sorting or grading terminology, NOT both, should be used for a given project.

2.7.5 Angularity or Rounding

Geological terms that are used to describe the general appearance of visible grains in the soil sample. This term is useful in determining the origin and depositional environment of a material. Water transported materials may be rounded. Glacial tills will be more angular.

- **Angular** – Particles have sharp edges and relatively plane sides with unpolished surfaces.
- **Subangular** – Particles are similar to angular description but have rounded edges.
- **Subrounded** – Particles have nearly plane sides but have well-rounded corners and edges.
- **Rounded** – Particles have smoothly curved sides and no edges.

2.7.6 Shape

A term used to describe the shape of gravel, cobbles, and boulders. Terms are as follows where the particle shape shall be described based on the ratio of the dimensions where the length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle.

- **Flat** – Particles with width:thickness > 3.
- **Elongated –** Particles with length:width > 3.
- **Flat and Elongated –** Particles meet criteria for both flat and elongated.

2.7.7 Odor

Soils containing a significant amount of organic material may have a distinct odor of decaying vegetation. Soils may also have a petroleum, sewage or chemical type odor. Note the type of odor but avoid trying to identify the specific chemical; any contaminants in the soil should be identified only by chemical analysis. **Caution - Safety Note**: Odors should be noted if observed. However soil samples may contain contaminants that are harmful if inhaled. Field personnel should NOT inhale deeply near the sample in an attempt to better determine if an odor is present.

Olfactory characteristics are subject to field conditions such as temperature and wind, as well as individual nasal sensitivities. The strength of the odor may also be noted (e.g., strong or slight).

2.7.8 Cementation

Describe the cementation of intact coarse-grained soils as follows.

- **Weak** – Crumbles or breaks with handling or little finger pressure.

- **Moderate** – Crumbles or breaks with considerable finger pressure.
- **Strong** – Will not crumble or break with finger pressure.

2.7.9 Hydrochloric Acid Reaction (HCl)

As appropriate for the geologic environment, describe the reaction with HCl as none, weak, or strong. As calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid (1 part 10N HCl to 3 parts water) is appropriate for certain projects.

- **None** – No visible reaction.
- **Weak** – Some reaction, with bubbles forming slowly.
- **Strong** – Violent reaction, with bubbles forming immediately.

2.8 Fine Grained Soils

Fine grained soils can be identified based on several manual field tests described below.

2.8.1 Dilatancy

Dilatancy is the appearance/disappearance of surface water during shaking, indicating a change in the pore volume of the material during deformation. Of the fine grained soils, silts are more likely to exhibit dilatancy. In order to test for dilatancy, obtain a small sample of soil and mold into a ½-inch diameter ball adding water as needed until the sample is soft but not sticky. Flatten the ball with the blade of a knife or spatula and shake the sample horizontally striking the side of the hand with the other hand. Note the rate at which water appears on the surface of the sample, if any. Squeeze the sample and note the reaction of the water, if any. Describe the dilatancy of the sample as follows:

Description	Criteria
None	No visible water at surface
Slow	Water appears slowly on shaking, does not disappear or disappears slowly on squeezing
Rapid	Water appears quickly on shaking, disappears quickly on squeezing

2.8.2 Toughness and Plasticity

Toughness is a measure of the amount of effort required to roll a 1/8-inch thick thread of soil at the plastic limit. Plasticity is a property of the soil that is exhibited when the soil is at a specific water content known as the plastic limit; that is, the degree at which soil is permanently deformed without rupturing by force applied in any direction.

2.8.2.1 Toughness Procedure

Roll a sample of the soil against a flat surface or between the palms of the hand to a thickness of 1/8-inch. If the thread crumbles and breaks prior to reaching the 1/8-inch thickness, add water and repeat. If the sample is too wet to roll easily, dry the sample by spreading into a thin layer or re-rolling repeatedly. The sample is at the plastic limit when the soil breaks apart and crumbles just when the thread reaches the 1/8-inch thickness. Note the pressure required to roll the thread at the plastic limit, the strength of the thread, and the pressure required to mold the sample back into a lump.

Describe the toughness of the sample as follows:

Description	Criteria
Low	Slight pressure required to roll the thread and the thread and lump are soft and weak
Medium	Moderate pressure required to roll the thread and the thread and lump have medium stiffness
High	Considerable pressure required to roll the thread and the thread and lump have very high stiffness

2.8.2.2 Plasticity Procedure

Soil plasticity is a measure of the soil's ability to be molded into a shape, and is the primary mechanism for distinguishing between silt and clay in the field. Silts are non-plastic; they are non-cohesive and cannot be molded and shaped. Clays exhibit varying degrees of plasticity. The plasticity of the soil can be determined using the observations made during the toughness test. Based on those observations, the plasticity of the soil can be described as follows:

Description	Criteria
Nonplastic	The soil cannot be molded at any water content
Low	When moistened the soil can be molded into a ball or cylinder. A 1/8-inch diameter thread may be formed if kept very moist, but crumbles easily if dried slightly.
Medium	When moistened a 1/8-inch thread of soil is easy to roll. Crumbles if manipulated.
High	When moistened a 1/8-inch thread of soil is easy to roll. Thread does not crumble easily even if bent and manipulated.

2.8.3 Identification of Fine Grained Soils

Fine grained soils can be identified using the dilatancy, toughness and plasticity tests and the criteria identified in the following table. These criteria should only be used for inorganic soils.

Soil Type	Dilatancy	Toughness	Plasticity
Silt	Slow to Rapid	Low	Nonplastic to Low
Elastic Silt	None to Slow	Low to Medium	Low to Medium
Lean Clay	None to Slow	Medium	Medium
Fat Clay	None	High	High

2.8.4 Identification of Organic Soils

Organic soils contain enough organic particles to influence the soil properties and usually have a dark brown to black color and often have an organic odor. Organic soils are typically fine grained and are identified as either organic silts or clays. Peat is a particular type of organic soil composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor. When present the sample shall be designated as highly organic soil or peat. Laboratory tests are usually required to differentiate between organic silts and clays.

2.9 Fill Soils

Frequently soils are encountered that have been placed in an area for the purpose of changing or modifying the surface elevation. These fill soils can be reworked native soils or soils imported from another location. Indications that a soil is a non-native fill material include the following:

- The presence of anthropogenic materials (e.g., bricks, concrete, plastic);
- A heterogeneous mixture of soils with a random or unnatural distribution;
- Soils with an unnatural particle size distribution (e.g., clean pea stone).

Environmental and geotechnical projects often require that the extent and depth of fill soils be characterized. Fill soils are usually considered unsuitable for geotechnical uses due to the potential variation of soil types and engineering properties, and the uncertain compaction history of the material.

Fill soils can also contain anthropogenic materials that can be sources of contamination. Examples of anthropogenic materials that can be sources of contamination include the following:

- Construction and demolition debris especially with coatings or materials that contain tar or asphalt;
- Ash;
- Slag;
- Coal; and
- Asphalt pavement.

Regardless of the potential for contamination, all anthropogenic materials should be listed in the soil description. Contact the Project Manager immediately if any of these materials are unexpectedly encountered. This is especially important if environmental samples are being collected for site characterization.

2.10 Geologic Origin

Where possible based on existing site data, local research, or geologic understanding of the local region, include the apparent geologic origin of the material, such as glacial deposit (e.g., till, outwash), aeolian deposit, residual soil, colluvium, alluvium, regolith, residuum, saprolite, or fill material. Do not utilize geologic origin if not certain.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pick-up and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Other than having another person peer review and duplicate the visual identification, samples of identified soils can be submitted to a geotechnical laboratory for classification in accordance with *ASTM D 2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. The laboratory classification can then be compared to the visual identification which can be changed as needed. It is recommended that Project Managers include laboratory classification of site soils in work plans for environmental projects. Laboratory classification should always be included for geotechnical projects. TRC field staff shall consult the site-specific work plan to determine laboratory soil classification requirements, if any.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All soil identification information must be documented in the field book and/or on an appropriate field form (TRC Sample Log Sheet, Boring Logs, Test Pit Logs or gINT). Example field forms are included in Attachment A. Field notes should neatly convey the soil descriptions. Providing soil classifications following this SOP will allow for consistent data interpretation and increase project efficiency when soil descriptions are taken from field logs and converted to electronic report logs (e.g., gINT). Record the following information in the field book:

- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was taken
- Personnel performing the task
- Visual description of the sample
- Weather conditions during sampling
- Other pertinent observations as prescribed in TRC's SOP for field activity documentation

6.0 REFERENCES

ASTM D2487 *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System),* Annual Book of ASTM Standards, Vol. 04.08, Current edition.

ASTM D2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure),* Annual Book of ASTM Standards, Vol. 04.08, Current edition.

ASTM D1586-11 *Standard Test Method for Standard Penetration Test (SPT) and Split Barrel-Sampling of Soils*, Annual Book of ASTM Standards, Vol. 04.08, Current edition.

Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

Procedures for Testing Soils. Burmister, D.M., 1958. Suggested Methods of Test for Identification of Soils.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	SEPTEMBER 2013	NOT APPLICABLE

ATTACHMENT A
FIELD FORMS

TRC
Soil Boring Log

Project/Client	Project No.	Boring No. / Well No.	Sheet 1 of __
Location Description		TRC Geologist	
Drilling Contractor/Foreman	Drill Rig Make/Model	Auger/Drive Casing Size/Type	
Sampler Description	Drilling Method	Coordinates X= Y=	
Filter Seal Amount/Type:	Drill Bit/Auger Diameter:	Ref. El.:	
Sand Pack Amount/Type:	Hammer Weight/Fall:	Riser Stick Up:	
Screen Length/Type:	Water Table Depth:	Surface Elevation:	
Riser Length/Type:	Total Depth:	Date Start:	Date Finish:

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction
	S-1							
1								
2	S-2							
3								
4	S-3							
5								
6	S-4							
7								
8	S-5							
9								
10	S-6							
11								
12	S-7							
13								

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions Used
trace 0-10% some 20-35%
little 10-20% and 35-50%

Cohesive Soils

Blows/ft	Density
<2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

1)

2)

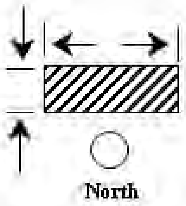
3)

TRC
Test Pit Log

Equipment/Contractor Used:	Project:	Date/Time:	Sheet ___ of ___
	Contractor Personnel:	TRC Personnel:	
	Location:	Test Pit Number:	
Reach/Capacity:	Total Depth:	Piezometer Installed?	
Depth to Ground Water:	Weather:	Elevation:	Top of Pit ______

Depth	Sample Number	Stratigraphic Description	REMARKS:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS BURMISTER USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

GRAIN SIZE (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. Sand	2.0-0.43 mm
c. Sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Rev: February 2006

PAGE ______ OF ______

LOG OF SOIL BORING

PROJECT NAME:		SOIL BORING ID:	
PROJECT NUMBER:		LOCATION:	SHEET 1 OF
LOGGED BY:			SURFACE ELEV.:
PROJECT LOCATION:		N: E:	DATE STARTED:
DRILLED BY:	DRILLER NAME:		DATE COMPLETED:

NO.	TYPE	%	BLOWS	PID	DEPTH	VISUAL CLASSIFICATION AND OBSERVATIONS	COMMENT
					2.5		
					5.0		
					7.5		
					10.0		
					12.5		
					15.0		
					17.5		
					20.0		

DRILLING METHOD:
DRILL RIG:
BORING DIAMETER:

WATER LEVEL OBSERVATIONS			
FIRST OCCURRENCE:			
DATE	TIME	DEPTH TO WATER	DEPTH TO BOTTOM

SIGNED DATE CHECKED DATE

REVISED 06/2011

ATTACHMENT B

USCS FIELD REFERENCE SHEETS

GENERAL NOTES - BORING LOGS (UNIFIED SOIL CLASSIFICATION SYSTEM)

SAMPLE DESCRIPTION FORMAT

Group Name (Group Symbol), Percent and Range of Particle Sizes, Plasticity, Color, Odor, Moisture, Density, Additional Comments, Geological Origin (Stratigraphic Unit)

USCS CLASSIFICATION

MAJOR DIVISIONS		SYM	TYPICAL NAMES AND DESCRIPTIONS
COARSE GRAINED (more than 50% > no. 200 sieve)	GRAVELS (more than 50% of coarse fraction > no. 4 sieve)	GW	Well graded gravels or gravel/sand mixtures; little or no fines
		GP	Poorly graded gravels or gravel/sand mixtures; little or no fines
		GM	Silty gravels, gravel/sand/silt mixtures
		CC	Clayey gravels, gravel/sand/clay mixtures
	SANDS (more than 50% of coarse fraction < no. 4 sieve)	SW	Well graded sands or gravelly sands; little or no fines
		SP	Poorly graded sands or gravelly sands; little or no fines
		SM	Silty sands, sand/silt mixtures
		SC	Clayey sands, sand/clay mixtures
FINE GRAINED (more than 50% < no. 200 sieve)	SILTS AND CLAYS High Liquid Limit (> 50)	ML	Inorganic silts, silty or clayey fine sands, clayey silts; low plasticity
		CL	Inorganic clays, silty/sandy/gravelly clays; low to medium plasticity (lean)
		OL	Organic silts and organic silty clays; low plasticity
	SILTS AND CLAYS Low Liquid Limit (< 50)	MH	Inorganic silts, elastic silts
		CH	Inorganic clays with high plasticity (fat clays)
		OH	Organic clays, medium to high plasticity or organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic silts

DENSITY

RELATIVE DENSITY				
COHESIVE			NONCOHESIVE	
DESCRIPTION	N-VALUE[1]	q_u (tsf)[2]	DESCRIPTION	N-VALUE[1]
Very Soft	0 - 2	< 0.25	Very Loose	0 - 4
Soft	2 - 4	0.25 - 0.50	Loose	4 - 10
Medium	4 - 8	0.50 - 1.0	Medium Dense	10 - 30
Stiff	8 - 15	1.0 - 2.0	Dense	30 - 50
Very Stiff	15 - 30	2.0 - 4.0	Very Dense	> 50
Hard	> 30	> 4.0		

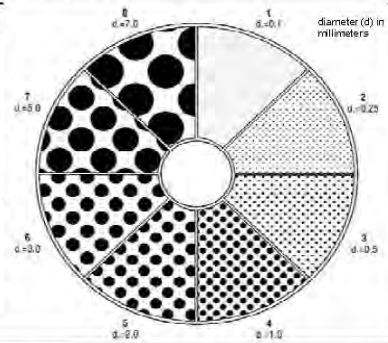
[1] Number of blows of 140 LB hammer falling 30 inches to drive a 2-in O.D. split-barrel sampler the last 12 inches of an 18-in drive (ASTM 1586 Standard Penetration Test).
[2] Compressive Strength in tons per square foot (tsf) (typically measured with a pocket penetrometer).

PLASTICITY

DESC.	CRITERIA
Nonplastic	The soil cannot be molded at any water content
Low	When moistened the soil can be molded into a ball/cylinder. A 1/8-in diameter thread may be formed if kept very moist, but crumbles easily if dried slightly.
Medium	When moistened a 1/8 thread of soil is easy to roll. Crumbles if manipulated.
High	When moistened a 1/8 thread of soil is easy to roll. Thread does not crumble easily even if bent and manipulated.

GRAIN SIZE

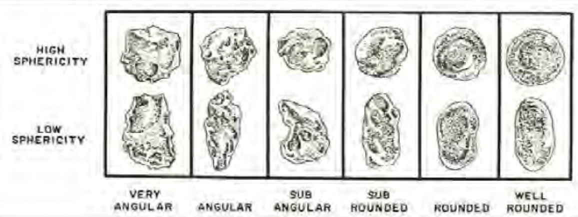
GRAIN SIZE			GRADE DESCRIPTION	
MM	INCHES	SIEVE SIZE		
300	12	--	--	BOULDER
75	3	--	--	COBBLE
19	0.75	--	COARSE	GRAVEL
4.75	0.19	4	FINE	
2.0	0.08	10	COARSE	SAND
0.425	0.02	40	MEDIUM	
0.075	0.003	200	FINE	
<0.075	<0.003	325	--	SILT
<0.075	<0.003	--	--	CLAY



MOISTURE

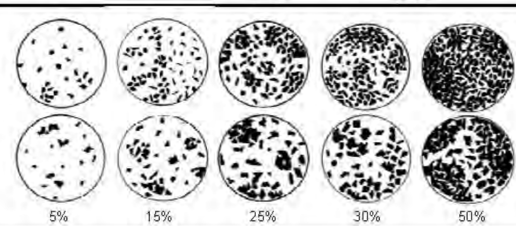
DESC.	CRITERIA
Dry	Absense of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below the water table

GRAIN SHAPE



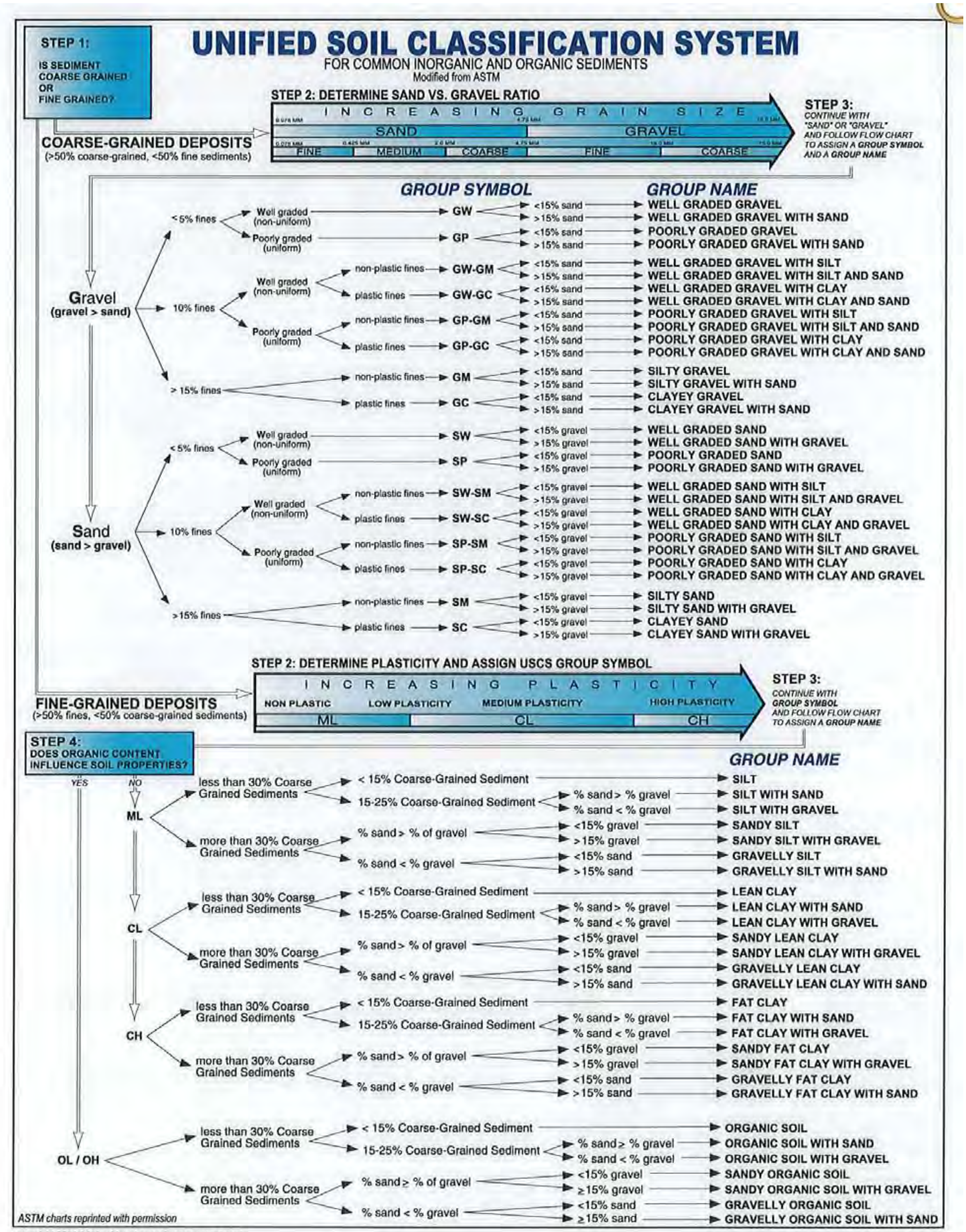
GRAIN DISTRIBUTION

PROPORTIONS	
DESC.	% RANGE
Trace	< 5%
Few	5% - 10%
Little	15% - 25%
Some	30% - 45%
Mostly	> 50%



ADDITIONAL INFORMATION TO BE INCLUDED IN FIELD NOTES

- Project/Boring Indentification
- Contractor/Crew Identification
- Date/Time of Contractor Operations
- Equipment Identification
- Sample Identification
- Sampled Interval
- Recovery
- Drilling Challenges/Resolution
- Sample Chain of Custody
- Well Construction
  - Materials
  - Screen Length/Slot Size
  - Screen Depth
  - Filter Pack Depth
  - All Seal Depth(s)
  - Riser Pipe Length (Stick-up/flush mount)


STEP 1:
IS SEDIMENT COARSE GRAINED OR FINE GRAINED?
UNIFIED SOIL CLASSIFICATION SYSTEM
FOR COMMON INORGANIC AND ORGANIC SEDIMENTS
Modified from ASTM
STEP 2: DETERMINE SAND VS. GRAVEL RATIO
INCREASING GRAIN SIZE
SAND
GRAVEL
FINE
MEDIUM
COARSE
FINE
COARSE
STEP 3:
CONTINUE WITH "SAND" OR "GRAVEL" AND FOLLOW FLOW CHART TO ASSIGN A GROUP SYMBOL AND A GROUP NAME
COARSE-GRAINED DEPOSITS
(>50% coarse-grained, <50% fine sediments)
GROUP SYMBOL
GROUP NAME
Gravel
(gravel > sand)
<5% fines
10% fines
> 15% fines
Well graded (non-uniform)
Poorly graded (uniform)
non-plastic fines
plastic fines
GW
GP
GW-GM
GW-GC
GP-GM
GP-GC
GM
GC
<15% sand
>15% sand
WELL GRADED GRAVEL
WELL GRADED GRAVEL WITH SAND
POORLY GRADED GRAVEL
POORLY GRADED GRAVEL WITH SAND
WELL GRADED GRAVEL WITH SILT
WELL GRADED GRAVEL WITH SILT AND SAND
WELL GRADED GRAVEL WITH CLAY
WELL GRADED GRAVEL WITH CLAY AND SAND
POORLY GRADED GRAVEL WITH SILT
POORLY GRADED GRAVEL WITH SILT AND SAND
POORLY GRADED GRAVEL WITH CLAY
POORLY GRADED GRAVEL WITH CLAY AND SAND
SILTY GRAVEL
SILTY GRAVEL WITH SAND
CLAYEY GRAVEL
CLAYEY GRAVEL WITH SAND
Sand
(sand > gravel)
SW
SP
SW-SM
SW-SC
SP-SM
SP-SC
SM
SC
<15% gravel
>15% gravel
WELL GRADED SAND
WELL GRADED SAND WITH GRAVEL
POORLY GRADED SAND
POORLY GRADED SAND WITH GRAVEL
WELL GRADED SAND WITH SILT
WELL GRADED SAND WITH SILT AND GRAVEL
WELL GRADED SAND WITH CLAY
WELL GRADED SAND WITH CLAY AND GRAVEL
POORLY GRADED SAND WITH SILT
POORLY GRADED SAND WITH SILT AND GRAVEL
POORLY GRADED SAND WITH CLAY
POORLY GRADED SAND WITH CLAY AND GRAVEL
SILTY SAND
SILTY SAND WITH GRAVEL
CLAYEY SAND
CLAYEY SAND WITH GRAVEL
STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL
INCREASING PLASTICITY
NON PLASTIC
LOW PLASTICITY
MEDIUM PLASTICITY
HIGH PLASTICITY
ML
CL
CH
STEP 3:
CONTINUE WITH GROUP SYMBOL AND FOLLOW FLOW CHART TO ASSIGN A GROUP NAME
FINE-GRAINED DEPOSITS
(>50% fines, <50% coarse-grained sediments)
STEP 4:
DOES ORGANIC CONTENT INFLUENCE SOIL PROPERTIES?
YES
NO
GROUP NAME
ML
CL
CH
OL / OH
less than 30% Coarse Grained Sediments
more than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
15-25% Coarse-Grained Sediment
% sand > % gravel
% sand < % gravel
% sand > % of gravel
% sand ≥ % gravel
% sand ≥ % of gravel
<15% gravel
>15% gravel
≥15% gravel
<15% sand
>15% sand
≥15% sand
SILT
SILT WITH SAND
SILT WITH GRAVEL
SANDY SILT
SANDY SILT WITH GRAVEL
GRAVELLY SILT
GRAVELLY SILT WITH SAND
LEAN CLAY
LEAN CLAY WITH SAND
LEAN CLAY WITH GRAVEL
SANDY LEAN CLAY
SANDY LEAN CLAY WITH GRAVEL
GRAVELLY LEAN CLAY
GRAVELLY LEAN CLAY WITH SAND
FAT CLAY
FAT CLAY WITH SAND
FAT CLAY WITH GRAVEL
SANDY FAT CLAY
SANDY FAT CLAY WITH GRAVEL
GRAVELLY FAT CLAY
GRAVELLY FAT CLAY WITH SAND
ORGANIC SOIL
ORGANIC SOIL WITH SAND
ORGANIC SOIL WITH GRAVEL
SANDY ORGANIC SOIL
SANDY ORGANIC SOIL WITH GRAVEL
GRAVELLY ORGANIC SOIL
GRAVELLY ORGANIC SOIL WITH SAND
ASTM charts reprinted with permission

ATTACHMENT C

SOP FACT SHEET

SOIL CLASSIFICATION PROCEDURES

PURPOSE AND OBJECTIVE

The objective of this method is to standardize the collection and documentation of information on soil that is useful for the purpose of hydrogeological or geotechnical evaluation of a site. The use of standardized visual examination and manual test methods by all field personnel results in standardized data that can be evaluated later for geologic and engineering uses.

Soil samples may be collected by various means, as discussed in TRC's Soil Sampling SOP. Regardless of the sample collection method, the resulting soil sample should be visually described and characterized. Visual examination of the sample will result in identifying grain size, particle size percentages, geologic and geotechnical modifiers and/or classifications, and a host of secondary characteristics.

WHAT TO BRING

- Field book, boring logs, test pit logs (as applicable)
- A copy of boring logs or field notes from previous work performed at or near the site
- Pocket penetrometer or miniature vane shear device
- Munsell Soil Color Chart
- Burmister and/or Unified Soil Classification System (USCS) classification chart/reference sheets
- Sand grading chart
- Camera
- Appropriate knife
- Spoon and/or small spatula
- Tape measure, folding ruler or yard stick
- Portable table
- Polyethylene sheeting
- Hand lens
- Equipment decontamination supplies
- Deionized water in squeeze bottle
- Small squirt bottle with dilute hydrochloric acid (1 part 10N HCl to 3 parts water)PID
- Garbage bags

OFFICE

- Prepare/update the HASP; make sure the field team is familiar with the latest version.
- Discuss the objective for the soil sampling program with the project manager and/or the field lead. Discuss sample order, collection method, designation, analytical parameters, turn-around times, laboratory, etc.
  - Are the soil cuttings to be containerized in drums or returned to borehole?
  - Field decontamination required?
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure, test equipment and make sure it is in proper working order.
- Verify that a utility survey/mark-out has been performed to ensure that sample locations are clear of overhead and buried utilities. Obtain a copy of the markout ticket or confirmation number. Additionally, a private geophysical sub-surface survey may be necessary.

ON-SITE

- Verify that underground utilities have been marked out and that the markouts are clear. Stay at least two feet away from any marked utility. Identify if any overhead obstructions or limited access areas exist near proposed borings and contact the Project Manager if any proposed locations need to be moved. Sketch/photograph markout locations.
- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.).
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.

MODIFIED BURMISTER SOIL CLASSIFICATION SYSTEM

The general description of a soil sample should be in the following order:

1. Color
2. Major Constituent – capitalized
3. Minor Constituent(s)
4. Geologic modifiers or classifications (e.g., glacial deposit, fill material) in parentheses
5. Density
6. Moisture content
7. Modifiers for fine fraction of sample (plasticity, dilatancy and toughness)
8. Other significant observations (e.g., odors, staining, sheen, petroleum product, debris)

SOIL CLASSIFICATION PROCEDURES

Use the following guidelines when recording soil descriptions:

-If the major constituent comprises more than 50% of the soil, then fully capitalize the major component descriptor (e.g., SAND);
-If the major constituent comprises less than 50% of the soil, capitalize the descriptor (e.g., Sand);
-Place a comma after the major and minor constituent descriptors;
-Place size qualifiers such as coarse, medium, or fine before the major constituent descriptors;
-Use the appropriate adjectives for proportions (e.g., and, some, little, trace) when describing the minor fraction(s); and
-Use the modifiers for fine grained soils described (plasticity, dilatancy and toughness).

EXAMPLE 1: Tan, medium SAND, little fine sand, trace coarse sand, trace silt, stratified (Outwash), loose, wet.

EXAMPLE 2: Gray, CLAY, soft, wet, medium plasticity, no dilatancy and low toughness.

When logging a soil sample collected from a boring (e.g., split spoon or acetate liner) where more than one soil type is present, describe each one separately, using additional line(s) on the boring log form. Start the description from the top and log each change in stratigraphy in sequence to the bottom. Record the length (e.g., 0-0.5 ft.) at the beginning of each separate sequence description, followed by a colon. Draw a line below the bottom of the complete sample description.

USCS CLASSIFICATION SYSTEM

The USCS is based on grain size and response to physical manipulation at various water contents. This system is often used for classifying soils encountered in boreholes, test pits, and surface sampling. The following properties form the basis of USCS soil classification:

- Percentage of gravel, sand, and fines;
- Shape of the grain size distribution curve; and
- Plasticity and compressibility characteristics.

Four soil fractions are recognized: cobbles, gravel, sand, and fines (silt or clay). The soils are divided as coarse grained soils, fine grained soils, and highly organic soils. Soil description should be concise and stress major constituents and characteristics for fine-grained, organic, or coarse-grained soils.

The general description of a soil sample should be in the following order:

1. Group Name (Group Symbol)
2. Percent and Range of Particle Sizes
3. Plasticity
4. Color (Munsell Color Chart)
5. Odor
6. Moisture
7. Density
8. Additional Comments
9. Geological Origin (Stratigraphic Unit)

EXAMPLE 1: Well Graded Gravel with Sand (GW): mostly fine to coarse subangular gravel, little fine to coarse subangular sand, yellowish brown (10YR 5/4), no odor, moist, loose, few small cinders, fill.

EXAMPLE 2: Silt (ML): mostly silt, non-plastic, gray (7.5YR 5/1), slight hydrocarbon odor, moist, medium dense, lacustrine.

The USCS recognizes 15 soil groups and uses names and letters to distinguish between these groups. The flow charts included in Attachment B: USCS Field Reference Guide, for fine- and coarse-grained soils, can be used to assign the appropriate group symbol(s) and name and are replicated from ASTM D2488. If the soil has properties which do not distinctly place it into a specific group, borderline symbols (example SP-SM, GP-GC, etc.) may be used.

GRAIN SIZE

Grain size classification should be based on the following method.

COARSE GRAINED PARTICLES

Boulder: > 300 mm (>12 in.)
Cobble: 75 - 300 mm (3 in. – 12 in.)
Coarse Gravel: 19 - 75 mm (¾ in. – 3 in.)
Fine Gravel: 4.75 - 19 mm (No. 4 sieve – ¾ in.)
Coarse Sand: 2.0 - 4.75 mm (No. 10 sieve – No. 4 sieve)
Medium Sand: 0.425 - 2.0 mm (No. 40 sieve – No. 10 sieve)
Fine Sand: 0.075 - 0.425 mm (No. 200 sieve – No. 40 sieve)

FINE GRAINED PARTICLES

Note that these particle sizes cannot be visually differentiated with standard field equipment. Silts and clays are distinguished in the field by cohesion and plasticity.

2

SOIL CLASSIFICATION PROCEDURES

PROPORTIONS

Proportions of grain sizes need to be described in accordance with one of the two following classification systems. Note that in either system minor constituents also include ancillary materials such as mica flakes, dark minerals, naturally occurring organic matter, or anthropogenic material (e.g., fill, brick, concrete).

Modified Burmister:
For geologic description, proportions of grain sizes will be based upon the following nomenclature:

Trace:	0-10%
Little:	10-20%
Some:	20-35%
And:	35-50%

The major soil sample constituent is always capitalized and listed first.

USCS:
For geologic description, proportions of grain sizes will be based upon the following nomenclature:

Trace:	< 5%
Few:	5-10%
Little:	15-25%
Some:	30-45%
Mostly:	> 50%

COLOR

The main color value should be stated, along with a modifier, if appropriate. For example *light brown* or *reddish brown*

EXAMPLE 1: Gray, poorly sorted angular fine to medium SAND, some silt, trace angular coarse sand, trace clay (lodgement glacial till), slightly mottled, dense, moist *(Modified Burmister description)*

EXAMPLE 2: Well Graded Sand (SW), mostly angular fine to medium sand, little to some silt, few angular coarse sand, few clay, gray, no odor, moist, dense, lodgement glacial till. *(USCS description)*

As with other components of soil classification, consistent soil color descriptions can be very helpful when preparing subsurface interpretations from soil data collected by different personnel. To that end, the use of Munsell Soil Color charts may be implemented to standardize color nomenclature. Just as paint stores have pages of color chips, soil scientists use a book of color chips that follow the Munsell System of Color Notation. The system has three components: Hue (a specific color), Value (lightness and darkness) and Chroma (color intensity). For example, a brown soil may be noted as: hue value/chroma (10YR 5/3).

RELATIVE DENSITY

The modifiers used to describe soil relative density depend on whether the soil is cohesive (i.e. clay) or granular/non-cohesive (gravel, sand or silt). Field evaluation of the density of non-cohesive soils is based the ease of penetration by the sampling equipment used. The density of cohesive soils is based the compressive soil strength of soil or soil stiffness (i.e. how much the soil compresses under a given pressure).

Density can be directly measured in the field, such as with the ASTM 1586: Standard Penetration Test during split spoon sample collection or with a pocket penetrometer. Alternatively, the density can be measured qualitatively, such as the ease of thumb penetration.

MOISTURE CONTENT

Moisture content should be described using the following modifiers:

- Dry – no apparent moisture, dusty.
- Moist – slight moisture content but no visible water, soils may stick together.
- Wet – water dripping from sample; usually soil is below the water table

GEOLOGIC MODIFIERS

Sedimentological descriptions aid in the geologic classification of a soil material. Only insert geologic modifiers when present.

- **Stratification**
  The presence of alternating layers of non-cohesive materials of different grain sizes or color with layers at least 6 mm thick. Note thickness of layers.
- **Lamination or Varves**
  The presence of alternating very thin layers of fine materials or color, such as silt and clay, with layers less than 6 mm thick. Note thickness of layers.
- **Sorting**
  A geological term used to describe how close in size the grains in a sample are to each other.

SOIL CLASSIFICATION PROCEDURES

- **Grading**

An engineering term used to describe the range in grain sizes present in a sample.

- **Angularity or Rounding**

Geological terms that are used to describe the general appearance of visible grains in the soil sample.

➢ Angular – Particles have sharp edges and relatively plane sides with unpolished surfaces.
➢ Subangular – Particles are similar to angular description but have rounded edges.
➢ Subrounded – Particles have nearly plane sides but have well-rounded corners and edges.
➢ Rounded – Particles have smoothly curved sides and no edges.

- **Shape**

A term used to describe the shape of gravel, cobbles, and boulders.

➢ Flat – Particles with width:thickness > 3.
➢ Elongated – Particles with length:width > 3.
➢ Flat and Elongated – Particles meet both criteria.

- **Odor**

Soils containing a significant amount of organic material may have a distinct odor of decaying vegetation. Soils may also have a petroleum, sewage or chemical type odor.

- **Cementation**

Describe the cementation of intact coarse-grained soils as follows.

➢ Weak – Crumbles or breaks with handling or little finger pressure.
➢ Moderate – Crumbles or breaks with considerable finger pressure.
➢ Strong – Will not crumble or break with finger pressure.

FINE GRAINED SOILS

Dilatancy

Dilatancy is the appearance/disappearance of surface water during shaking, indicating a change in the pore volume of the material during deformation. Flatten the ball with the blade of a knife or spatula and shake the sample horizontally striking the side of the hand with the other hand. Note the rate at which water appears on the surface of the sample, if any. Squeeze the sample and note the reaction of the water, if any. Describe the dilatancy as follows:

➢ None: no visible water at surface
➢ Slow: water appears slowly on shaking, does not disappear or disappears slowly on squeezing
➢ Rapid: water appears quickly on shaking, disappears quickly on squeezing

Toughness and Plasticity

Toughness is a measure of the amount of effort required to roll a 1/8-inch thick thread of soil at the plastic limit. Plasticity is a property of the soil that is exhibited when the soil is at a specific water content known as the plastic limit; that is, the degree at which soil is permanently deformed without rupturing by force applied in any direction.

Soil plasticity is a measure of the soil's ability to be molded into a shape, and is the primary mechanism for distinguishing between silt and clay in the field. Silts are non-plastic; they are non-cohesive and cannot be molded and shaped. Clays exhibit varying degrees of plasticity. The plasticity of the soil can be determined using the observations made during a toughness test.

FILL SOILS

Frequently soils are encountered that have been placed in an area for the purpose of changing or modifying the surface elevation. These fill soils can be reworked native soils or soils imported from another location. Indications that a soil is a non-native fill material include the following:

- The presence of anthropogenic materials (e.g., bricks, concrete, plastic);
- A heterogeneous mixture of soils with a random or unnatural distribution;
- Soils with an unnatural particle size distribution (e.g., clean pea stone).

Environmental and geotechnical projects often require that the extent and depth of fill soils be characterized. Fill soils are usually considered unsuitable for geotechnical uses due to the potential variation of soil types and engineering properties, and the uncertain compaction history of the material.

Fill soils can also contain anthropogenic materials that can be sources of contamination. Examples of anthropogenic materials that can be sources of contamination include the following:

- Construction and demolition debris especially with coatings or materials that contain tar or asphalt;
- Ash;
- Slag;
- Coal; and
- Asphalt pavement.

Title: **Headspace Field Screening Procedure**	Procedure Number: **RMD 014**
	Revision Number: **0**
	Effective Date: **April 2015**

Authorization Signatures

Jamie Stapleton	Elizabeth Denly
Technical Reviewer — Date Jamie Stapleton — 4/10/15	Remediation Practice Quality Coordinator — Date Elizabeth Denly — 4/10/15

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting headspace field screening measurements of solid and aqueous samples during field investigations. This SOP does not cover screening for health & safety purposes or well mouth and tank headspace.

1.2 Summary of Method

The objective of headspace field screening is to obtain organic vapor/gas measurements of solid or aqueous media encountered during solid or aqueous sampling. The procedure involves collecting solid or aqueous samples, sealing them in airtight containers, and analyzing the Total Organic Vapors (TOVs) that form within the container using a portable vapor/gas detector.

Headspace field screening data can be used to pre-screen field samples or as a guide to direct subsequent investigations. Data collected using these methods are considered qualitative and specific compounds cannot be distinguished.

1.3 Equipment

The following list of equipment may be utilized when conducting headspace field screening measurements. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Photoionization detector (PID) with appropriate electron volt (eV) lamp source (see Section 1.6.2 for selection of proper lamp source) or flame ionization detector (FID)
- Aluminum foil
- 500 ml clean jars or larger (for solid samples) - jars less than 8 oz. capacity should not be used
- One quart or one gallon resealable plastic bags (for solid samples)
- 40 ml to 1,000 ml clean jars (for aqueous samples)
- Field book
- Charcoal filter (for FID only, if methane present)
- Moisture filter/external water trap (for PID only)
- Tedlar bag(s)
- Isobutylene (100 parts per million by volume [ppmV], at a minimum): compressed gas cylinder (for PID)
- Methane (100 ppmV, at a minimum): compressed gas cylinder (for FID)
- Zero air: compressed gas cylinder or carbon filter with ambient air

- Sharpie pen

1.4 Definitions

FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured by the detector.
Headspace	The area/space between the sample media and the top of the airtight container holding the sample. Organic vapors, if present, will collect in this area/space and can be measured.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured by the detector.
VOCs	Any chemical compound based on carbon chains or rings with a vapor pressure greater than 2 mm of mercury.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Implementing this SOP will require the use of compressed gases for portable meter calibration. These gases may be hazardous materials and TRC will appropriately transport, handle and store them at all times.

1.6 Cautions and Potential Problems

1.6.1 Environmental Factors

Environmental factors may influence the performance of these methods. These factors include:

1. High moisture in soil or sediment. High moisture levels in soil/sediment can limit the amount of contaminants that volatilize into the container headspace. High moisture levels affect PID readings more than FID readings and may cause a positive or negative bias or inconsistent and non-comparable readings. For this reason, headspace field screening readings of aqueous samples using a PID may not be appropriate. A water trap or filter should be used with a PID to reduce these impacts.

2. A slowly increasing response on a PID may result from moisture levels interfering with instrument measurements. Instrumentation with digital (LED/LCD) displays may not be able to discern maximum headspace response unless equipped with a maximum hold feature or strip-chart recorder.

3. High organic levels in soil or sediment and organic matter in aqueous samples. Contaminants can sorb onto organic matter (i.e., leaves, peat), which can limit the amount of contaminants that volatilize into the container headspace and may cause inconsistent or non-comparable readings. The presence of organic matter in aqueous samples (i.e., microbial populations) can reduce volatilization of contaminants. High levels of organics in soil/sediment and aqueous

samples may also produce methane, a natural gas that is included in the TOV readings from FIDs, but not recorded by PIDs. A charcoal filter may be used with an FID to remove the methane from the vapor sample.

4. Limited pore space due to fines (e.g., clay or silt). It may be difficult to generate headspace measurements in a tight clay matrix.
5. Meteorological variations, especially humidity and ambient temperature. Normal ambient temperature variations could affect the amount of vapors that form in the headspace. Very cold temperatures will limit volatilization of VOCs. Increasing ambient temperature as the day progresses will result in more volatilization and higher readings, an effect that needs to be considered when using the data to make decisions. PIDs may not be able to operate in heavy rain so the Project Manager should be consulted if inclement weather is expected.
6. Background ambient levels of VOCs. Before beginning a headspace field screening program, identify background ambient levels of VOCs. Taking these levels into account when interpreting headspace field screening measurements will minimize the potential for false measurements. Data may be corrected for background measurements; however, the use of this procedure will be determined on a site-specific basis by the Project Manager.
7. Be aware of where the headspace readings are being obtained. Locations near potential sources of VOCs, such as operating vehicles, operating generators, or air handling equipment at a site, may contribute to transient volatile conditions and be a source of bias.
8. Certain instruments have multiple operating ranges. If the sample yields headspace field screening results higher than the upper limit of calibration, recalibration to accommodate a higher range may be necessary.

1.6.2 Ionization Potentials of Contaminants of Concern

The ionization potential of the contaminant is the energy required to completely remove an electron from its atom. In general, the ultraviolet lamp in the PID will either be 10.6 eV or 11.7 eV. When selecting the proper lamp, the ionization potential of the contaminant(s) of concern must be less than the ionization potential of the lamp. For example, if a PID is equipped with a 10.6 eV lamp, it will generally detect compounds with ionization potentials less than or equal to 10.6 eV. For most compounds, a 10.6 eV lamp is sufficient. Refer to Attachment B for a list of compounds and their ionization potentials. Two examples of proper lamp selection are provided below:

Example 1: Trichloroethene: Ionization potential = 9.47 eV.
Since the ionization potential is less than 10.6 eV, either the 10.6 eV or the 11.7 eV lamp could be used.

Example 2: 1,1,1-Trichloroethane: Ionization potential = 11 eV
Since the ionization potential is greater than 10.6 eV but is less than 11.7 eV, only the 11.7 eV lamp could be used.

It should also be noted that the life of an 11.7 eV lamp is considerably shorter (i.e., 1-3 months) than that of a 10.6 eV lamp (i.e., up to 3 years).

1.6.3 High Levels of Methane

If samples are suspected of containing high levels of methane (e.g., high levels of decaying organics or sites undergoing natural or enhanced degradation), representative readings of non-methane hydrocarbon vapors may be inhibited when using an FID. To avoid methane interference, a PID should be used or if an FID is used, it should be equipped with a charcoal filter on the inlet which will filter out all compounds except methane and ethane; the heavier organic compounds are adsorbed onto the charcoal filter. Measurements can be taken with and without the charcoal filter to determine the levels of methane/ethane in the sample and TOVs, respectively. The use of a PID and one FID (without a filter) or two FIDs (one with a charcoal filter and one without a charcoal filter) may be considered in order to obtain simultaneous readings.

- Measurement without charcoal filter = TOV Concentration (including methane and ethane)
- Measurement with charcoal filter = Methane and Ethane Concentration
- Measurement without charcoal filter – Measurement with charcoal filter = Total Non-Methane/Ethane Hydrocarbons provided that the sample only contains hydrocarbons and no other VOCs that would be detected by the FID.

NOTE: The loading capacity (amount of hydrocarbons which can be adsorbed on the charcoal filter before breakthrough will occur) and lifetime of the charcoal filter must be verified with the vendor prior to use. Depending on project needs, it may be advisable to have a supply of charcoal on hand to replace spent filter material.

1.6.4 Use of Headspace Field Screening Data

It is important to note that measurements obtained using portable vapor/gas detectors such as a PID or FID are considered qualitative and semi-quantitative. This type of data is sufficient for demonstrating the relative presence of contamination, determining "hot spots," and using as a guide to direct subsequent investigations. This type of field screening data cannot be used to identify specific contaminants and should not be used to determine whether a sample is "clean."

1.6.5 Use of Thermal Enhancement for Headspace Measurements

Certain compounds (e.g., xylenes and other high molecular weight VOCs) yield a better response when the headspace screening is performed with thermal enhancement. Thermal enhancement of a sample can be performed using direct sunlight, a heated vehicle, a heated building, a hot water bath, or a hot lamp. Refer to site-specific plans to determine the need for thermal enhancement. Thermal enhancement may also be useful for headspace screening in cold weather situations.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the site-specific work plan and/or Quality Assurance Project Plan (QAPP), if applicable, for any site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Attachment B lists the ionization potentials of specific compounds. Refer to Section 1.6.2 for instruction on selecting a PID with an appropriate lamp.

2.1 Calibration Procedures

PID and FID field instruments shall be operated and calibrated to yield TOVs in ppm volume/volume (v/v) as isobutylene for the PID and methane for the FID. In certain instances, other gases may be appropriate for calibration. Correction of results using response factors may be appropriate; refer to the instrument manufacturer's manuals for the proper procedure. Batteries of the PID and FID should be checked prior to the beginning of the field event. Following calibration, response checks should periodically be performed throughout the day to demonstrate the responsiveness of the instrument. These checks can be performed by exposing the PID or FID to the tip of a Sharpie pen; the performance of this check and the presence of instrument response must be documented in the field notes. General calibration procedures are as follows:

PID AND FID

1. Turn the instrument on and allow it to warm up for at least 10 minutes.
2. Fill a separate tedlar bag ¼ full with zero air; depress the bag completely to expel any miscellaneous gases trapped in the bag. Fill the bag full with zero air. Alternatively, clean ambient air can be used instead of a tedlar bag filled with zero air.
3. Set the PID or FID to the appropriate zero gas Calibration Mode.
4. Attach the probe to the tedlar bag, open the bag valve, and begin the calibration mode on the instrument. Keep the bag attached until the meter finishes the calibration. Alternatively, expose the probe to clean ambient air until the meter finishes the calibration.
5. Fill a tedlar bag ¼ full with the isobutylene standard for the PID or the methane standard for the FID. Depress the bag completely to expel any miscellaneous gases trapped in the bag. Fill the bag full with the isobutylene standard (PID) or methane standard (FID). Alternatively, the instrument can be connected directly to the compressed gas standard cylinder.
6. Set the instrument to the appropriate span gas Calibration Mode. Enter the appropriate calibration gas concentration in the meter.
7. Attach the probe to the tedlar bag, open the bag valve, and begin the calibration mode on the instrument. Keep the bag attached until the meter finishes the calibration. Alternatively, attach the probe directly to the compressed gas standard cylinder, open the cylinder valve, and begin the calibration mode on the instrument; keep the cylinder attached until the meter finishes the calibration.
8. Calibration should be performed in accordance with the site-specific work plan, at least at the beginning of the day. Calibration checks should be performed as necessary. Calibration

should be checked if there is a substantial change in weather, if you have moved from an indoor location to an outdoor location (or vice versa), or if inconsistent or non-comparable readings are observed. The calibration check is performed using the compressed gas standard followed by the zero air check. The measured value of the standard must be within $\pm$10% of the true value. The zero air check should not yield a reading above background. All calibration measurements must be recorded in the field book or on a field data form (see Attachment A).

2.2 Field Screening Procedures

The following procedures should be followed for headspace field screening measurements of solid and aqueous samples. For solid samples, a re-sealable plastic bag may be substituted for clean jars; however, this depends on site-specific requirements and must be verified with the Project Manager. Soil samples collected for field screening should not be used for laboratory chemical analysis due to potential loss of volatile contaminants in the sample from sample handling. Sample collection for headspace field screening and laboratory analysis of VOCs should occur as soon as possible (i.e., preferably within minutes) after the sample is exposed to air to minimize loss of TOVs due to volatilization.

1. Put on chemical-resistant gloves.

2. Fill a clean container one-third to one-half full with the sample to be analyzed. The type and size of the container, as well as the amount of sample collected, should be consistent for all samples collected at a site. See Section 1.3 for appropriate size containers for each matrix.

3. Quickly cover the open container top with one sheet of clean aluminum foil and apply the screw cap to tightly seal the jar. Plastic bags filled with soil should be sealed.

4. Vigorously shake the jar or bag for approximately 15 seconds. Be sure that all samples are shaken for approximately the same period of time.

5. Allow headspace development to occur for at least 10 minutes. The time allowed for headspace development should be approximately the same for all samples; differences should be noted. Where ambient temperatures are near or below 32ºF (0ºC), thermal enhancement of the sample may be considered and modified via direct sunlight, a heated vehicle or building, a hot water bath, a hot lamp, or similar. Site-specific conditions (e.g., sunlight, wind) may impact the actual temperature. Otherwise, headspace development can occur at ambient temperatures. Headspace development should not be allowed to occur so long that condensation forms in the container.

6. Determine the background ambient level of TOVs. Record this value in the field book.

7. Vigorously shake jar for approximately 15 seconds after the headspace development period. Be sure that all samples are shaken for approximately the same period of time.

8. Subsequent to headspace development, unscrew and remove lid to expose aluminum foil seal. Be sure to hold edge of foil during the removal of the lid to ensure the foil seal remains in place. Quickly puncture aluminum foil seal with instrument sampling probe, and insert probe to a point about one-half of the headspace depth. Alternatively, for solid samples in a re-sealable bag, partially open the seal, insert the probe into the bag, and re-seal the zipper

around the probe. Exercise care to avoid uptake of water droplets or soil particulates into the instrument.

9. Following probe insertion through the aluminum foil seal or into the plastic bag, record the highest meter response as the headspace concentration. Using the aluminum foil seal/probe insertion method, maximum response should occur between 2 and 5 seconds.

10. The headspace screening data should be recorded in the field book and/or on a field data form (see Attachment A).

11. All headspace screening waste should be returned to the original source site location or disposed of in accordance with Section 3.0.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste (IDW) disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following procedures should be used for collecting headspace field screening measurements:

1. Operate and calibrate field instruments according to the manufacturer's manuals.

2. Headspace measurements should be performed in duplicate on one sample each day, at a minimum. This requires collection of two separate aliquots of sample. All procedures, including the amount of time allowed for headspace development and the number of seconds the containers are shaken, should be the same for each container. Ensure that both of the containers are in the same environment during headspace development (e.g., both jars are in the sun, both jars are in a heated car).

3. The results of duplicate samples should be compared; generally, the relative percent differences (RPDs) of the replicate values should be $\leq$20 when readings are greater than 10 ppmV. RPDs may be higher when readings are less than or equal to 10 ppmV. If the RPD of the replicate values is not within these criteria, make sure that the cautions and potential problems listed in Section 1.6 were not encountered during the headspace measurements. If none of these factors were encountered, perform a calibration check to ensure the instrument is working properly. Document the test results as well as any performance or calibration checks in the field book. RPD is calculated using the following equation:

$$\mathrm{RPD} = \frac{\text{Reading } 1 - \text{Reading } 2}{(\text{Reading } 1 + \text{Reading } 2)/2} \mathrm{X}\,100$$

5.0 Data Management and Records Management

All procedures and field screening results must be documented in the field book and/or on an appropriate field data form. Refer to Attachment A for an example of headspace field screening results documentation. Correction of headspace measurements for background values may be performed; the use of this procedure will be determined on a site-specific basis by the Project Manager. Any deviations from the headspace field screening procedures specified in this SOP, a site-specific work plan, or a site-specific QAPP must be approved by the Project Manager as well as documented in the field book. In such cases, compelling technical justification must be presented and documented for the methodology employed. Refer to RMD SOP 001 for field documentation procedures.

6.0 References

Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

Expedited Site Assessment Tools For Underground Storage Tank Sites. EPA 510/B-97/001. March 1997.

Attachment 11, Interim Remediation Waste Management Policy for Petroleum Contaminated Soils. MassDEP WSC-94-400. April 1994.

Commonwealth of Massachusetts Underground Storage Tank Closure Assessment Manual. MassDEP WSC-402-96. April 9, 1996.

RAE Systems, Inc. Technical Note TN-106, *A Guideline for PID Instrument Response*, 07/16.

7.0 SOP Revision History

Revision Number	Revision Date	Reason for Revision
0	April 2015	Not Applicable

Attachment A

Example Documentation for Headspace Field Screening Results

Headspace Field Screening Log

Site Name ___________________________
Site Location ________________________
TRC Personnel________________________

Instrument Used (make/model)____________________
Calibration Gas Used/Concentration________________
Matrix/Sampling Method__________________________

Sample ID	Location	Depth	Date/Time	Background Reading (ppmV)	Screening Results (ppmv)			Comments	Instrument/Lamp Used
					Reading 1	Reading 2	RPD		
Soil Boring – 01, 2-4'			*8/5/03-0700*	*2*	*24.6*	*25.3*	*2.8*	*South side of excavation*	*PID / 10.2 eV*
Soil Boring – 02, 0-2'			*8/5/03-0815*	*2*	*1.5*	*1.2*	*22*	*North side of excavation*	*PID / 10.2 eV*

ppmV = parts per million by volume
RPD = relative percent difference

Attachment B

Photoionization Characteristics of Selected Compounds

NR – No Response
IE – Ionization Energy
C – Confirmed values (correction factors) indicated by "+" in this column; all others are preliminary or estimated values and are subject to change
ne – Not Established ACGIH 8-hr. TWA
C## - Ceiling value, given where 8-hr. TWA is not available
TWA – Time-weighted average

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C_2H_4O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	$C_2H_4O_2$	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	$C_4H_6O_3$	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C_3H_6O	1.2	+	0.9	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C_4H_7NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C_2H_3N					100		12.19	40
Acetylene	Ethyne	74-86-2	C_2H_2					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C_3H_4O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	$C_3H_4O_2$			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C_3H_3N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C_3H_6O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C_3H_5Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	NH_3	NR	+	10.9	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	$C_7H_{14}O_2$	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	$C_5H_{12}O$			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C_6H_7N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C_7H_8O	0.89	+	0.58	+	0.56	+	8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH_3			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C_7H_6O					1		9.49	ne
Benzene		71-43-2	C_6H_6	0.55	+	0.47	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C_7H_5N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C_7H_8O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C_7H_7Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	$C_8H_8O_2$	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF_3	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br_2	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C_6H_5Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C_3H_7OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	$CHBr_3$	NR	+	2.7	+	0.5	+	10.48	0.5
Bromopropane,1-	n-Propyl bromide	106-94-5	C_3H_7Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C_4H_6	0.8		0.6	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	$C_4H_6O_2$	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C_4H_{10}			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	$C_4H_{10}O$	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Butyl alcohol	75-65-0	$C_4H_{10}O$	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C_4H_8			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	$C_6H_{14}O_2$	1.8	+	1.2	+	0.6	+	<10	25
Butoxyethyl Acetate, 2-	2-Butoxyethyl acetate; 2-Butoxyethanol acetate; Butyl Cellosolve acetate; Butyl glycol acetate; EGBEA; Ektasolve EB acetate	112-07-2	$C_8H_{16}O_3$			1.27	+				20
Butyl acetate, n-		123-86-4	$C_6H_{12}O_2$			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	$C_7H_{12}O_2$			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	$C_4H_{11}N$	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve see 2-Butoxyethanol		111-76-2									
Butyl hydroperoxide, t-		75-91-2	$C_4H_{10}O_2$	2.0	+	1.6	+			<10	1

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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Butyl mercaptan	1-Butanethiol	109-79-5	$C_4H_{10}S$	0.55	+	0.52	+			9.14	0.5
Butyraldehyde	Butanal	123-72-8	C_4H_8O			1.87	+			9.82	20
Camelinal HRJ						1.1	+	0.32	+		
Camelinal HRJ/JP-8 50/50						0.89	+	0.41	+		
CamelinalHRJ						1.15	+				
CamelinalHRJ/JP-8						1.07	+				
Carbon disulfide		75-15-0	CS_2	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl_4	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve see 2-Ethoxyethanol											
CFC-14 see Tetrafluoromethane											
CFC-113 see 1,1,2-Trichloro-1,2,2-trifluoroethane											
Chlorine		7782-50-5	Cl_2					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO_2	NR	+	NR	+	NR	+	10.57	0.1
Chlorobenzene	Monochlorobenzene	108-90-7	C_6H_5Cl	0.44	+	0.55	+	0.39	+	9.06	10
Chlorobenzotrifluoride, 4-	PCBTF, OXSOL 100 p-Chlorobenzotrifluoride	98-56-6	$C_7H_4ClF_3$	0.74	+	0.63	+	0.55	+	<9.6	
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C_4H_5Cl			3					10
Chloro-1,1-difluoroethane, 1-	HCFC-142B, R-142B	75-68-3	$C_2H_3ClF_2$	NR		NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	$CHClF_2$	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C_2H_5Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlrohydrin	107-07-3	C_2H_5ClO							10.52	C1
Chloroethanol, 2-	2-Chloroethanol; 2-Chloroethyl alcohol; Ethylene chlorhydrin	107-07-3	C_2H_5ClO			2.88	+			10.5	5
Chloroethyl ether, 2-	bis (2-chloroethyl) ether	111-44-4	$C_4H_8Cl_2O$	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C_3H_7ClO			3					ne
Chloroform	Trichloromethane	67-66-3	$CHCl_3$	NR	+	NR	+	3.5	+	11.37	10
Chloro-2-methylpropene, 3-	Methallyl chloride, Isobutenyl chloride	563-47-3	C_4H_7Cl	1.4	+	1.2	+	0.63	+	9.76	ne
Chloropicrin		76-06-2	CCl_3NO_2	NR	+	~400	+	7	+		0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C_7H_7Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C_7H_7Cl					0.6		8.69	ne
Chlorotrifluoroethene	CTFE, Chlorotrifluoroethylene Genetron 1113	79-38-9	C_2ClF_3	6.7	+	3.9	+	1.2	+	9.76	5
Chlorotrimethylsilane		75-77-4	C_3H_9ClSi	NR		NR		0.82	+	10.83	ne
Cresol, m-	m-Hydroxytoluene, 3-Methylphenol	108-39-4	C_7H_8O	0.57	+	0.50	+	0.57	+	8.29	5
Cresol, o-	ortho-Cresol; 2-Cresol; o-Cresylic acid; 1-Hydroxy-2-methylbenzene; 2-Hydroxytoluene; 2-Methyl phenol	95-48-7	C_7H_8O			1	+			8.14	5
Cresol, p-	para-Cresol; 4-Cresol; p-Cresylic acid; 1-Hydroxy-4-methylbenzene; 4-Hydroxytoluene; 4-Methyl phenol	106-44-5	C_7H_8O			1.4	+			8.34	5
Crotonaldehyde	trans-2-Butenal	123-73-9 4170-30-3	C_4H_6O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C_9H_{12}	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C_6H_{12}	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	$C_6H_{12}O$	1.5	+	0.9	+	1.1	+	9.75	50
Cyclohexanone		108-94-1	$C_6H_{10}O$	1.0	+	0.9	+	0.7	+	9.14	25

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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Cyclohexene		110-83-8	C_6H_{10}			0.8	+			8.95	300
Cyclohexylamine		108-91-8	$C_6H_{13}N$			1.2				8.62	10
Cyclopentane 85% 2,2-dimethylbutane 15%		287-92-3	C_5H_{10}	NR	+	15	+	1.1		10.33	600
Cyclopropylamine	Aminocyclpropane	765-30-0	C_3H_7N	1.1	+	0.9	+	0.9	+		ne
Decamethylcyclopentasiloxane		541-02-6	$C_{10}H_{30}O_5Si_5$	0.16	+	0.13	+	0.12	+		ne
Decamethyltetrasiloxane		141-62-8	$C_{10}H_{30}O_3Si_4$	0.17	+	0.13	+	0.12	+	<10.2	ne
Decane		124-18-5	$C_{10}H_{22}$	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	$C_6H_{12}O_2$			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	$CHBr_2Cl$	NR	+	5.2	+	0.7	+	10.59	ne
Dibromo-3-chloropropane, 1,2-	DBCP	96-12-8	$C_3H_5Br_2Cl$	NR	+	1.7	+	0.43	+		0.001
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	$C_2H_4Br_2$	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	$C_6H_4Cl_2$	0.54	+	0.64	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl_2F_2			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	$C_2H_6Cl_2Si$	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	$C_2H_4Cl_2$			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	$C_2H_2Cl_2$			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	c-1,2-DCE, *cis*-Dichloroethylene	156-59-2	$C_2H_2Cl_2$			0.8				9.66	200
Dichloroethene, t-1,2-	t-1,2-DCE, *trans*-Dichloroethylene	156-60-5	$C_2H_2Cl_2$			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	$C_2H_3Cl_2F$	NR	+	NR	+	2.0	+		ne
Dichloromethane see Methylene chloride											
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoro-propane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-penta-fluoropropane (HCFC-225cb)	442-56-0 507-55-1	$C_3HCl_2F_5$	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	$C_3H_6Cl_2$					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	$C_3H_4Cl_2$	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	$C_3H_4Cl_2$	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1- trifluoroethane, 2,2-	R-123	306-83-2	$C_2HCl_2F_3$	NR	+	NR	+	10.1	+	11.5	ne
Dichloro-2,4,6- trifluoropyridine, 3,5-	DCTFP	1737-93-5	$C_5Cl_2F_3N$	1.1	+	0.9	+	0.8	+		ne
Dichlorvos**	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	$C_4H_7Cl_2O_4P$			0.9	+			<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	$C_{10}H_{12}$	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel**		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2 (Automotive)**		68334-30-5	m.w. 216	1.3		0.7	+	0.4	+		11
Diethylamine		109-89-7	$C_4H_{11}N$			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	$C_7H_{18}N_2$			1.3					ne
Diethylbenzene see Dowtherm J											
Diethyl ether	Diethyl ether; Diethyl oxide; Ethyl oxide; Ether; Solvent ether	60-29-7	$C_4H_{10}O$			1.74	+			9.51	400
Diethylene glycol butyl ether	2-(2-Butoxyethoxy)ethanol, BDG, Butyldiglycol, DB Solvent	112-34-5	$C_8H_{18}O_3$			4.6	+				5
Diethylene glycol monobutyl ether acetate	Butyldiglycol acetate, DB Acetate, Diethylene glycol monobutyl ether acetate	124-17-4	$C_{10}H_{20}O_4$			5.62	+				ne
Diethylmaleate		141-05-9	$C_8H_{12}O_4$			4					ne
Diethyl sulfide see Ethyl sulfide											
Diglyme see Methoxyethyl ether		111-96-6	$C_6H_{14}O_3$								

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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Diisobutyl ketone	DIBK, 2,2-dimethyl-4-heptanone	108-83-8	$C_9H_{18}O$	0.71	+	0.61	+	0.35	+	9.04	25
Diisopropylamine		108-18-9	$C_6H_{15}N$	0.84	+	0.74	+	0.5	+	7.73	5
Diisopropylcarbodiimide,N,N'-	DIPC	693-13-0	$C_7H_{14}N_2$			0.42	+				ne
Diisopropylethylamine	'Hünig's base', *N*-Ethyldiisopropylamine, DIPEA, Ethyldiisopropylamine	7087-68-5	$C_8H_{19}N$			0.7	+				ne
Diketene	Ketene dimer	674-82-8	$C_4H_4O_2$	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C_4H_9NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C_2H_7N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	$C_3H_6O_3$	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	$C_2H_6S_2$	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether see Methyl ether											
Dimethylethylamine	DMEA	598-56-1	$C_4H_{11}N$	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C_3H_7NO	0.7	+	0.7	+	0.8	+	9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	$C_2H_8N_2$			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	$C_3H_9O_3P$	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	$C_2H_6O_4S$	~23		~20	+	2.3	+		0.1
Dimethyl sulfide see Methyl sulfide											
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C_2H_6OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	$C_4H_8O_2$			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	$C_3H_6O_2$	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A see Therminol®**											
Dowtherm J (97% Diethylbenzene)**		25340-17-4	$C_{10}H_{14}$			0.5					
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C_2H_5ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C_2H_6			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C_2H_6O			9.6	+	3.1	+	10.47	1000
Ethanolamine**	MEA, Monoethanolamine	141-43-5	C_2H_7NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C_2H_4			9	+	4.5	+	10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	$C_4H_{10}O_2$			1.3				9.6	5
Ethyl acetate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	$C_4H_8O_2$			3.8	+			10.01	400
Ethyl acetoacetate		141-97-9	$C_6H_{10}O_3$	1.4	+	1.2	+	1.0	+	<10	ne
Ethyl acrylate		140-88-5	$C_5H_8O_2$			2.4	+	1.0	+	<10.3	5
Ethylactate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	$C_4H_8O_2$					2.18	+	10.01	400
Ethylamine		75-04-7	C_2H_7N			0.8				8.86	5
Ethylbenzene		100-41-4	C_8H_{10}	0.52	+	0.65	+	0.51	+	8.77	100
Ethyl caprylate	Ethyl octanoate	106-32-1	$C_{10}H_{20}O_2$		+	0.52	+	0.51	+		
Ethylenediamine	1,2-Ethanediamine; 1,2-Diaminoethane	107-15-3	$C_2H_8N_2$	0.9	+	0.8	+	1.0	+	8.6	10
(Ethylenedioxy)diethanethiol, 2,2'-	1,2-Bis(2-mercaptoethoxy)ethane, 3,6-Dioxa-1,8-octane-dithiol	14970-87-7	$C_6H_{14}O_2S_2$			1.3	+				ne
Ethylene glycol**	1,2-Ethanediol	107-21-1	$C_2H_6O_2$			16	+	6	+	10.16	C100
Ethylene glycol, Acrylate**	2-hydroxyethyl Acrylate	818-61-1	$C_5H_8O_3$			8.2				≤10.6	
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	$C_4H_{10}O_2$	1.1		1.1		0.7		9.2	ne

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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Ethylene glycol monobutyl ether acetate	1,2-Dimethoxyethane, Monoglyme	110-71-4	$C_4H_{10}O_2$	1.1		1.1		0.7		9.2	ne
Ethylene glycol, monothio		60-24-2	C_2H_6OS			1.5				9.65	
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C_2H_4O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	$C_4H_{10}O$			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	$C_7H_{14}O_3$	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	$C_3H_6O_2$					1.9		10.61	100
Ethyl-1-hexanol, 2-	Isooctyl alcohol	104-76-7	$C_8H_{18}O$			1.9	+				ne
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	$C_{11}H_{20}O_2$			1.1	+	0.5	+		ne
Ethylidenenorbornene	5-Ethylidene bicyclo(2,2,1) hept-2-ene	16219-75-3	C_9H_{12}	0.4	+	0.39	+	0.34	+	≤8.8	ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	$C_5H_{10}O_3$	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C_2H_6S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	$C_4H_{10}S$			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH_2O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH_3NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH_2O_2	NR	+	NR	+	9	+	11.33	5
Furfural	2-Furaldehyde	98-01-1	$C_5H_4O_2$			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	$C_5H_6O_2$			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	$C_5H_8O_2$	1.1	+	0.8	+	0.6	+		C0.05
Glycidyl methacrylate	2,3-Epoxypropyl methacrylate	106-91-2	$C_7H_{10}O_3$	2.6	+	1.2	+	0.9	+		0.5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	$C_2HBrClF_3$					0.6		11.0	50
HCFC-22 see Chlorodifluoromethane											
HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane											
HCFC-141B see 1,1-Dichloro-1-fluoroethane											
HCFC-142B see 1-Chloro-1,1-difluoroethane											
HCFC-134A see 1,1,1,2-Tetrafluoroethane											
HCFC-225 see Dichloropentafluoropropane											
Heptane, n-		142-82-5	C_7H_{16}	45	+	2.8	+	0.60	+	9.92	400
Heptanol, 4-	Dipropylcarbinol	589-55-9	$C_7H_{16}O$	1.8	+	1.3	+	0.5	+	9.61	ne
Hexamethyldisilazane, 1,1,1,3,3,3-**	HMDS	999-97-3	$C_6H_{19}NSi_2$			0.2	+	0.2	+	~8.6	ne
Hexamethyldisiloxane	HMDSx	107-46-0	$C_6H_{18}OSi_2$	0.33	+	0.27	+	0.25	+	9.64	ne
Hexane, n-		110-54-3	C_6H_{14}	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	$C_6H_{14}O$	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C_6H_{12}			0.8				9.44	30
HFE-7100 see Methyl nonafluorobutyl ether											
Histoclear (Histo-Clear)	Limonene/corn oil reagent		m.w. ~136	0.5	+	0.4	+	0.3	+		ne
Hydrazine**		302-01-2	H_4N_2	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN_3							10.7	
Hydrogen	Synthesis gas	1333-74-0	H_2	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen iodide**	Hydriodic acid	10034-85-2	HI			~0.6				10.39	
Hydrogen peroxide		7722-84-1	H_2O_2	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H_2S	NR	+	3.3	+	1.5	+	10.45	10
Hydroxyethyl acrylate, 2-	Ethylene glycol monoacrylate	818-61-1	$C_5H_8O_3$			8.2	+				ne

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Hydroxypropyl methacrylate		27813-02-1 923-26-2	$C_7H_{12}O_3$	9.9	+	2.3	+	1.1	+		ne
Iodine**		7553-56-2	I_2	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH_3I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	$C_7H_{14}O_2$	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C_4H_{10}			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	$C_4H_{10}O$	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C_4H_8	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate	2-methylpropyl ethanoate, β-methylpropyl acetate	110-19-0	$C_6H_{12}O_2$			2.1	+			9.97	150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	$C_7H_{12}O_2$			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	$C_3H_2ClF_5O$	NR	+	NR	+	48	+	~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C_8H_{18}			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C_5H_{12}			8.2					ne
Isophorone		78-59-1	$C_9H_{14}O$					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C_5H_8	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C_3H_8O	500	+	4.6	+	2.7		10.12	200
Isopropyl acetate		108-21-4	$C_5H_{10}O_2$			2.6				9.99	100
Isopropyl ether	Diisopropyl ether	108-20-3	$C_6H_{14}O$			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, F-40 Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, F-44, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		29
Jet fuel JP-8	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.94	+	0.3	+		30
Jet fuel A-1	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 145			0.67					34
Jet Fuel TS	Thermally Stable Jet Fuel, Hydrotreated kerosene fuel	8008-20-6 + 64742-47-8	m.w. 165	0.9	+	0.6	+	0.3	+		30
JP-10						0.7	+	0.5	+		
JP5, Petroleum/camelinal						1.05	+				
JP5/Petroleum						0.98	+				
Limonene, D-	(R)-(+)-Limonene	5989-27-5	$C_{10}H_{16}$			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate see Jet Fuels		8008-20-6									
MDI see 4,4'-Methylenebis (phenylisocyanate)											
Maleic anhydride	2,5-Furandione	108-31-6	$C_4H_2O_3$							~10.8	0.1
Mercapto-2-ethanol	β-Mercaptoethanol, 2-Hydroxyethylmercaptan, BME, Thioethylene glycol	60-24-2	C_2H_6OS			1.5	+			9.65	0.2
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C_9H_{12}	0.36	+	0.35	+	0.3	+	8.41	25
Methallyl chloride see 3-Chloro-2-methylpropene											
Methane	Natural gas	74-82-8	CH_4	NR	+	NR	+	NR	+	12.61	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH_4O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	$C_3H_8O_2$	4.8	+	2.4	+	1.4	+	10.1	5

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Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	$C_7H_{16}O$	2.3	+	1.2	+	0.9	+	<10	ne
Methoxyethyl ether, 2-	bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme	111-96-6	$C_6H_{14}O_3$	0.64	+	0.54	+	0.44	+	<9.8	ne
Methyl acetate		79-20-9	$C_3H_6O_2$	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	$C_4H_6O_2$			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH_5N			1.2				8.97	5
Methyl amyl ketone	MAK, 2-Heptanone, Methyl pentyl ketone	110-43-0	$C_7H_{14}O$	0.9	+	0.85	+	0.5	+	9.30	50
Methylaniline, N-	MA; (Methylamino) benzene; N-Methyl aniline; Methylphenylamine; N-Phenylmethylamin	100-61-8	C_7H_9N			0.68	+			7.32	2
Methyl bromide	Bromomethane	74-83-9	CH_3Br	110	+	1.7	+	1.3	+	10.54	1
Methyl-2-butanol, 2-	*tert*-Amyl alcohol, *tert*-Pentyl alcohol	75-85-4	$C_5H_{12}O$			1.62	+			10.16	100
Methyl t-butyl ether	MTBE, tert-Butyl methyl ether	1634-04-4	$C_5H_{12}O$			0.9	+			9.24	40
Methyl cellosolve see 2-Methoxyethanol											
Methyl chloride	Chloromethane	74-87-3	CH_3Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C_7H_{14}	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis (phenyl-isocyanate), 4,4'-**	MDI, Mondur M		$C_{15}H_{10}N_2O_2$	Very slow ppb level response							0.005
Methylene chloride	Dichloromethane	75-09-2	CH_2Cl_2	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C_2H_6O	4.8	+	3.1	+	2.5	+	10.03	ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3	C_4H_8O	0.86	+	1.0	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	$C_2H_6N_2$	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isoamyl ketone	MIAK, 5-Methyl-2-hexanone	110-12-3	$C_7H_{14}O$	0.8	+	0.76	+	0.5	+	9.28	50
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	$C_6H_{12}O$	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate		624-83-9	C_2H_3NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate		551-61-6	C_2H_3NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH_4S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	$C_5H_8O_2$	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	$C_5H_3F_9O$			NR	+	~35	+		ne
Methyl-1,5-pentanediamine, 2- (coats lamp)**	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	$C_6H_{16}N_2$			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	$C_5H_{12}O$			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C_5H_9NO	1.0	+	0.8	+	0.9	+	9.17	ne
Methyl salicylate**	Methyl 2-hydroxybenzoate	119-36-8	$C_8H_8O_3$	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C_9H_{10}			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C_2H_6S	0.49	+	0.44	+	0.46	+	8.69	ne
Methyl tertiary-butyl ether	MTBE, Methyl *tert*-butyl ether	1634-04-4	$C_5H_{12}O$			1.43	+			9.24	50
Methyl vinyl ketone	MVK, 3-Buten-2-one	78-94-4	C_4H_6O			0.93	+			9.65	ne
Methyltetrahydrofuran	2-MeTHF, Tetrahydro-2-methylfuran, Tetrahydrosilvan	96-47-9	$C_5H_{10}O$			2.44	+			9.22	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5 8052-41-3 68551-17-7	m.w. 144	1.0		0.69	+	0.38	+		100
Mineral Spirits	Viscor 120B Calibration Fluid, b.p. 156-207°C	8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100

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Monoethanolamine see Ethanolamine											
Mustard	HD, Bis (2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	$C_4H_8Cl_2S$			0.6					0.0005
Naphtha see VM & P Naphtha											
Naphthalene	Mothballs	91-20-3	$C_{10}H_8$	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C_4NiO_4			0.18				<8.8	0.001
Nicotine	3-(1-Methyl-2-pyrrolidyl)pyridine	54-11-5	$C_{10}H_{14}N_2$			1.98	+				ne
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	$C_6H_5NO_2$	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	$C_2H_5NO_2$					3		10.88	100
Nitrogen dioxide		10102-44-0	NO_2	23	+	16	+	6	+	9.75	3
Nitrogen trifluoride		7783-54-2	NF_3	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH_3NO_2					4		11.02	20
Nitropropane, 2-		79-46-9	$C_3H_7NO_2$					2.6		10.71	10
Nonane		111-84-2	C_9H_{20}			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C_{10}-C_{13}	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C_{13}-C_{14}	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octamethylcyclotetrasiloxane		556-67-2	$C_8H_{24}O_4Si_4$	0.21	+	0.17	+	0.14	+		ne
Octamethyltrisiloxane		107-51-7	$C_8H_{24}O_2Si_3$	0.23	+	0.18	+	0.17	+	<10.0	ne
Octane, n-		111-65-9	C_8H_{18}	13	+	1.8	+			9.82	300
Octene, 1-		111-66-0	C_8H_{16}	0.9	+	0.75	+	0.4	+	9.43	75
Pentachloropropane	1,1,1,3,3-pentachloropropane	23153-23-3	$C_3H_3Cl_5$					1.25	+		0.1
Pentane		109-66-0	C_5H_{12}	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid**	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix**	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C_2Cl_4	0.69	+	0.57	+	0.31	+	9.32	25
Propylene glycol methyl ether, 1-Methoxy-2-propanol	PGME	107-98-2	$C_6H_{12}O_3$	2.4	+	1.5	+	1.1	+		100
Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	PGMEA	108-65-6	$C_6H_{12}O_3$	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C_6H_6O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine (coats lamp)		7803-51-2	PH_3	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C_6H_7N			0.9				9.04	ne
Pinene, α-		2437-95-8	$C_{10}H_{16}$			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	$C_{10}H_{16}$	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C_5H_8	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C_3H_8			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C_3H_8O			5.5		1.7		10.22	200
Propene	Propylene	115-07-1	C_3H_6	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C_3H_6O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	$C_5H_{10}O_2$			3.5				10.04	200
Propyl acetate	Propylacetate; n-Propyl ester of acetic acid	109-60-4	$C_5H_{10}O_2$			2.27	+			10.04	200

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Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C_3H_9N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate**		108-32-7	$C_4H_6O_3$			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	$C_3H_8O_2$	18		4.2	+	1.6	+	<10.2	ne
Propylene glycol propyl ether	1-Propoxy-2-propanol	1569-01-3	$C_6H_{14}O_2$	1.3	+	1.0	+	1.6	+		ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C_3H_6O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C_3H_7N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C_3H_8S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C_5H_5N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C_4H_9N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol: 1-Methoxy-2-acetoxypropane)	107-98-2	$C_4H_{10}O_2$/ $C_6H_{12}O_3$			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	$C_4H_{10}FO_2P$			~3					
Shell SPK						1.26	+				
Shell SPK						1.29	+	0.4	+		
Shell SPK 50/50						1.02	+	0.41	+		
Shell SPK/JP-8						1.11	+				
Stoddard Solvent see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C_8H_8	0.45	+	0.43	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO_2	NR		NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF_6	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO_2F_2	NR		NR		NR		13.0	5
Tabun**	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	$C_5H_{11}N_2O_2P$			0.8					15ppt
Tallow HRJ						1.09	+				
Tallow HRJ						0.95	+	0.36	+		
Tallow HRJ/JP-8						1.14	+				
Tallow HRJ/JP-8 50/50						0.9	+	0.39	+		
Tetrachloroethane, 1,1,1,2-		630-20-6	$C_2H_2Cl_4$					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	$C_2H_2Cl_4$	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	$SiCl_4$	NR		NR		15	+	11.79	ne
Tetraethyllead	TEL	78-00-2	$C_8H_{20}Pb$	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	$C_8H_{20}O_4Si$			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	$C_2H_2F_4$			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C_2F_4			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF_4			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C_4H_8O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	$C_4H_{12}O_4Si$	10	+	1.9	+			~10	1
Therminol® D-12**	Hydrotreated heavy naphtha	64742-48-9	m.w. 160	0.8	+	0.51	+	0.33	+		ne
Therminol® VP-1**	Dowtherm A, 3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	$C_{12}H_{10}O$ $C_{12}H_{10}$			0.4	+				1
Toluene	Methylbenzene	108-88-3	C_7H_8	0.54	+	0.45	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	$C_9H_6N_2O_2$	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	$C_6H_3Cl_3$	0.7	+	0.9	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	$C_2H_3Cl_3$			NR	+	1	+	11	350

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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	$C_2H_3Cl_3$	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichoroethylene	79-01-6	C_2HCl_3	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH_3Cl_3Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	$C_2Cl_3F_3$			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	$C_6H_{15}N$	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	$C_6H_{15}O_3B$			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	$C_6H_{15}O_4P$	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	$C_2H_3F_3$					34		12.9	ne
Trimethylamine		75-50-3	C_3H_9N			0.9				7.82	5
Trimethylbenzene, 1,3,5- see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	$C_3H_9O_3B$			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	$C_3H_9O_4P$			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	$C_3H_9O_3P$			1.1	+		+	8.5	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	$C_{10}H_{16}$	0.37	+	0.4	+	0.29	+	~8	20
Undecane		1120-21-4	$C_{11}H_{24}$			2				9.56	ne
Varsol see Mineral Spirits											
Vinyl actetate		108-05-4	$C_4H_6O_2$	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C_2H_3Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C_2H_3Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C_8H_{12}	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride see 1,1-Dicholorethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C_6H_9NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B see Mineral Spirits —	Viscor 120B Calibration Fluid										
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naphtha	64742-89-8	m.w. 111 (C_8-C_9)	1.7	+	0.97	+				300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C_8H_{10}	0.50	+	0.44	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C_8H_{10}	0.56	+	0.45	+	0.43		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C_8H_{10}	0.48	+	0.39	+	0.38	+	8.44	100

* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H_2O_2 and NO_2 give weak response even when their ionization energies are well below the lamp photon energy.

** Compounds indicated in green can be detected using a MiniRAE 3000, UltraRAE 3000 or ppbRAE 3000 with slow response, but may be lost by adsorption on a MultiRAE, EntryRAE and AreaRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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Attachment C:

Quick Reference Sheet

HEADSPACE FIELD SCREENING PROCEDURE

Purpose and Objective

Headspace field screening measurements of soil and aqueous samples are conducted in order to obtain organic vapor/gas measurements during field investigations. Headspace field screening can be used as a guide to direct the collection of samples for laboratory testing, to look for evidence of contamination, and to direct subsequent investigations. Data collected during these methods are considered qualitative and specific compounds cannot be distinguished. The procedure involves collecting solid or aqueous samples, sealing them in an airtight container, and analyzing the organic vapors that form within the container using a portable vapor/gas detector.

What to Bring

- Site-specific HASP
- Appropriate PPE
- PID with appropriate electron volt lamp source, or FID
- Field book
- Aluminum foil for enclosing jars
- 500 ml clean jars or 1-quart or larger resealable plastic bags for solid samples
- 40 ml to 1,000 ml clean jars for aqueous samples
- Charcoal filter (for FID, if methane is present)
- Moisture filter/external water trap (for PID)
- Tedlar bags
- Isobutylene compressed gas cylinder (for PID; 100 ppmV)
- Methane compressed gas cylinder (for FID; 100 ppmV)
- Zero air compressed gas cylinder or carbon filter
- Sharpie

Office

- Prepare/update the site-specific HASP.
- Review the site-specific work plan.
- Set up procedures for management of IDW (e.g., soils used in screening).
- Confirm all required equipment is available.

On-Site

- Verify project HASP is available on site.
- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Establish a designated work area.
- Compressed gases used for calibration are hazardous materials and must be appropriately be transported, handled, and stored.
- Provide for the proper collection and management of all IDW.
- Verify that appropriate PPE is worn by all site personnel (including subcontractors) and the work area is safe.

Headspace Field Screening Procedures

1. Allow the instrument to warm up at least 10 minutes. Calibrate using zero air or ambient air. Record the results. Properly calibrate the PID or FID using the appropriate calibration gas. Calibrate at the beginning of the day and if conditions change during the day or if results become inconsistent.
2. Depending on site-specific requirements, a resealable plastic bag or container can be used for solid samples.
3. Use chemical-resistant gloves and PPE per the HASP.
4. Fill the screening container ⅓ to ½ full of the sample. Seal the bag, or if a jar is used, quickly cover the top with aluminum foil and screw on the cap.
5. Vigorously shake the bag or jar for 15 seconds. Shake each sample container consistently for a similar time.
6. Allow headspace development to occur for at least 10 minutes. The time allowed should be approximately the same for all samples. For ambient temperatures below 32°F, thermal enhancement of the sample may be considered using a heated vehicle or building, sunlight, hot lamp, etc. Headspace development should not be allowed to occur so long that condensation forms in the container.
7. Vigorously shake the container for approximately 15 seconds after headspace development, using approximately the same time period for all samples.

HEADSPACE FIELD SCREENING

8. Unscrew the lid of the jar to expose the aluminum foil seal. Quickly puncture the seal with the instrument probe, and insert the probe to about ½ of the headspace depth. For a resealable bag, partially open the seal, insert the probe, and re-seal the bag around the probe. Avoid contacting the probe with water droplets or soil particles.
9. Following probe insertion, record the highest meter response as the headspace concentration. Maximum response should be between 2 to 5 seconds.
10. A slowly increasing response on a PID may be due to high moisture levels. Repeat analysis may be needed taking care to avoid condensation or contact with moisture.
11. If the sample yields headspace readings higher than the upper limit of calibration, recalibration to a higher level may be necessary.
12. Record the headspace screening data in the field book and/or on a field data form.
13. Return the sample to the original source site location, or dispose of the sample in accordance with the IDW plan.

INVESTIGATION DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the site-specific work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site. Containerize, label, or manage all IDW as specified in the plan.

QA/QC, DATA MANAGEMENT AND RECORDS MANAGEMENT

1. Headspace measurements should be performed in duplicate on one sample per day, at a minimum.
2. Procedures followed for sample preparation should be the same for all samples.
3. Operate and calibrate the instruments according to the manufacturer's manual.
4. Record the model name and number of the instrument in the field book.
5. All procedures and results must be documented in the field book and/or field forms. Correct values for background, if appropriate.
6. Document any deviations from the procedures specified in the work plan or QAPP in the field book. Any deviations must be approved by the Project Manager.

DOS AND DON'TS OF HEADSPACE FIELD SCREENING

DOs:

- DO call the Project Manager or field team leader if unexpected conditions are encountered, or at least daily to update them on site work.
- DO use properly trained staff.
- DO check the instrument batteries before each day.
- DO manage IDW in accordance with project requirements.
- DO properly calibrate the instrument using the compressed gas standard. Perform periodic response checks throughout the day. Record the results in the field notes.
- DO consider environmental factors such as high moisture and high organic content in the sample. High moisture may make using a PID inappropriate. A water trap or filter should be used to reduce moisture impacts. High organic matter can also affect results.
- DO use thermal enhancement such as a heated vehicle or building, or sunlight, to warm the samples to achieve a better response in cold conditions.
- DO use the proper lamp source in the PID based on the ionization potential of the contaminant of concern.
- DO collect samples for headspace or laboratory analysis within minutes of being exposed to air to minimize loss due to volatilization.

DON'Ts:

- DON'T perform headspace screening near potential sources of VOCs such as operating vehicles, generators, or air handling equipment.
- DON'T use samples collected for headspace screening for laboratory analysis.
- DON'T sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc.; call the PM if this issue arises.

Title: **Equipment Decontamination**	Procedure Number: **ECR 010**
	Revision Number: **1**
	Effective Date: **December 2016**

Authorization Signatures

Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
James Peronto	12/15/16	Elizabeth Denly	12/15/16

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the procedures needed for decontamination of equipment used in the field during environmental investigations (e.g., sediment, soil, groundwater investigations). Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination.

The use of dedicated, disposable, new sampling equipment (e.g., disposable liners, plastic spoons, plastic or aluminum bowls) should be considered as an alternative to equipment decontamination and the subsequent generation of decontamination fluids.

1.2 Summary of Method

Equipment decontamination is used to remove potential contaminants from a sampling device or piece of field equipment prior to and between the collection of samples and is also used to limit personnel exposure to residual contamination that may be present on used field equipment.

Contaminants can be physically removed from equipment or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and nonabrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water, followed by a wash/rinse process using appropriate cleaning solutions. A solvent rinse may be required when organic contamination is present, and an acid rinse may be required when metals are parameters of interest. Equipment decontamination procedures can vary depending on the media being sampled and the type of sampling equipment being used. Disposal of decontamination fluids will be handled on a project-specific basis and will be in accordance with all applicable regulations.

1.3 Equipment

The following equipment may be utilized when decontaminating equipment. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment B for further details.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)

- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate (may be supplied by the laboratory or purchased from commercial vendors depending on project requirements)
- Pump sprayer
- Pressure sprayer
- Squeeze bottle filled with pesticide-grade hexane (option for organic analyses)
- Squeeze bottle filled with pesticide-grade methanol (option for organic analyses)
- Squeeze bottle filled with pesticide-grade isopropanol (option for organic analyses)
- Squeeze bottle filled with 10 percent nitric acid (option for metals analyses and stainless-steel equipment)
- Squeeze bottle filled with 1 percent nitric acid (option for metals analyses)
- Container (squeeze bottle to 5-gallon bucket) filled with potable water and a nonphosphate, laboratory-grade soap (approximately 1 tablespoon of soap to 5 gallons of water)
- Extra quantities of above listed liquids
- Potable water
- Containers, such as buckets or wash basins (the type and number of containers is dependent on the procedure)
- Scrub brushes
- Small wire brush
- Aluminum foil
- Polyethylene sheeting
- A container for decontamination of pumps and associated tubing.

1.4 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Samples containing chemical contaminants may be handled during implementation of this SOP. Certain decontamination fluids, including solvents and/or acids, are considered hazardous materials, and TRC employees will appropriately handle and store them at all times. Appropriately manage chemicals that pose specific toxicity or safety concerns, and follow any other relevant requirements as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Some hazardous substances may be incompatible with clothing or equipment and can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through

inhalation or skin contact or if exposed to heat/flame and they combust. Safety data sheets for chemicals handled by TRC personnel should be maintained in a designated location at the project site.

1.5 Cautions and Potential Problems

Special care should be taken when decontaminating equipment used for sampling for PFAS. Please refer to Attachment B for details.

- The use of deionized, distilled or organic-free water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been certified by the vendor as analyte-free and/or meets the project-specific requirements.

- Alconox®, Liquinox®, or other nonphosphate, concentrated, laboratory-grade soap may contain trace quantities of perchlorate.

- Avoid using an excessive amount of soap during decontamination procedures, as this could result in difficulty rinsing the soap residue off of the equipment. Typically the soap solution is prepared using 1 tablespoon of soap to 5 gallons of water.

- Use sufficient amount of decontamination fluid (e.g., acid or solvent rinses) so that the fluid flows over the equipment and runs off. Spraying the equipment with a minimal amount of decontamination fluid that does not run off is ineffective.

- Spent decontamination solutions are considered investigation-derived waste (IDW) and must be managed as directed by the site-specific field program. Project and regulatory requirements, chemical compatibility, ambient conditions and professional judgment should be used to determine the appropriate decontamination process with respect to combining and/or segregating decontamination fluids. Section 3 of this SOP provides more guidance on the disposal procedures.

- Several procedures can be established to minimize the potential for cross-contamination or analytical interference by decontamination fluids. For example:

  - The use of methanol in the decontamination procedure may not be appropriate if methanol is a contaminant of concern.

  - Isopropanol may be used as a substitute for methanol but may not be appropriate when collecting samples for volatile organic compound (VOC) analyses. Residual isopropanol on the equipment may cause substantial interferences in subsequent VOC analyses and may result in unnecessary dilutions and/or false positive results if isopropanol is not removed in subsequent decontamination steps. It should also be noted that the application of isopropanol to hot metal surfaces (e.g., a steam-cleaned split spoon) may cause oxidation of the isopropanol to acetone.

- If hexane is used in the decontamination procedure, caution should be used to ensure that the hexane is completely volatilized and the equipment is subsequently rinsed when samples are to be analyzed for VOCs and volatile petroleum hydrocarbons (VPH). Residual hexane on equipment could interfere with the VOC and VPH analyses and may result in unnecessary dilutions and/or false positive results.

- Cover monitoring and sampling equipment with protective material (i.e., aluminum foil, polyethylene sheeting, or Ziploc® bags) to minimize potential re-contamination after decontamination.

- Use disposable sampling equipment when appropriate to minimize the need for decontamination. Although disposable sampling tools are encouraged in order to minimize the generation of decontamination fluids, it should be noted that plastic tools may not be appropriate for collection of samples to be analyzed for semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Potential phthalate contamination may cause significant interferences in the subsequent analyses and may result in unnecessary dilutions and/or false positive results.

- After decontamination, equipment should be handled only by personnel wearing clean disposable powder-free nitrile gloves to prevent recontamination.
- If equipment decontamination is performed in the field, the equipment should be moved away (preferably upwind) from the decontamination area to prevent recontamination.
- Equipment that is not decontaminated properly may result in potentially high biased results in field samples. **Note:** Equipment blank collection may be appropriate after decontamination of equipment used to collect highly contaminated samples.

1.6 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the site-specific sampling plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes.

2.1 General

All personnel, sample containers, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants by abrasive and/or washing actions, inactivate contaminants by disinfection or sterilization, or both. Decontamination procedures should be documented in the field book.

2.2 Physical Decontamination Procedures

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and nonabrasive methods. In general, heavy equipment decontamination is conducted by drilling and construction subcontractors and not by TRC personnel. However, TRC personnel will typically need to document such decontamination efforts as part of project work.

ABRASIVE CLEANING METHODS APPROPRIATE FOR DRILLING EQUIPMENT (DRILLING RIGS, ETC.)

Abrasive cleaning methods involve rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available but are not commonly used:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- *Air Blasting:* Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs, or auger bits. The equipment used in air blasting employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive material strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages, including it is unable to control the amount of materials removed, it can aerate contaminants, and it generates large amounts of waste.

- *Wet Blasting:* Wet blasting, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. One disadvantage of this method is the generation of a large amount of waste.

NONABRASIVE CLEANING METHODS APPROPRIATE FOR FIELD EQUIPMENT (DRILLING AUGERS AND RIGS, ETC.)

Nonabrasive cleaning methods involve forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using nonabrasive methods. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. The following non-abrasive methods are available:

- *High-pressure Potable Water:* This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high-pressure hose. Flow rates typically range from 20 to 140 liters per minute.

  This procedure is used the majority of the time and is more appropriate for equipment with painted surfaces.

- *Ultrahigh-Pressure Potable Water:* This system produces a pressurized water jet. The ultrahigh-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 meters per second (m/sec) to 900 m/sec. Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

  This procedure is not commonly used but would be appropriate for carbon steel drilling rods and augers.

2.3 Procedure for Sampling Equipment

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. **Note:** The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. The number of decontamination steps and designated containers should be determined prior to field sampling based on the site-specific sampling plan. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. If more than one, the nonwater rinsate fluids may need to be separated. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. Place the containers on the polyethylene sheeting. The decontamination line should progress from “dirty” to “clean”.

   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.

2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container. Do not use an excessive amount of the soap (approximately 1 tablespoon of soap to 5 gallons of water), or rinsing the soap residue off of the equipment will be difficult.

3. Brush any visible dirt off of the sampling equipment into a designated area before getting equipment wet.

4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container, removing all dirt or visible hydrocarbons. Allow excess soap to drain off the equipment into the container when finished. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

5. Rinse the equipment with potable water over an appropriate container, using a coarse scrub brush or pressure sprayer to aid in the rinse if necessary. If an additional acid or solvent rinse is not required, proceed to Step 8.

6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.

   Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Cautions and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.

   Allow the equipment to completely air dry prior to proceeding to the next step.

   **** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.**

8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container) (See*NOTE).

   ***NOTE** that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water

should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field book or on the appropriate form.

10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.

11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

12. Record the decontamination procedure in the field book or on the appropriate form.

2.4 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers, water level indicators, oil/water interface probes, and soil moisture/pH meters will be cleaned using the following procedure, unless it conflicts with the manufacturer's recommendations. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details.

1. Fill two clean containers (e.g., plastic wash basins or buckets) with potable water.

2. Add sufficient nonphosphate concentrated laboratory-grade soap to one container to form a thin layer of soap suds. If oily residues are apparent, the use of Simple Green® may be required.

3. Brush any visible dirt off of the measuring equipment before getting the equipment wet.

4. Either spray rinse the device with the soap solution over the first container, or for heavily soiled equipment, immerse the device in the container containing soap and gently agitate. Scrub device if it is soiled. Do not submerse any electrical controls or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

5. Immerse the device in the container containing the potable water and gently agitate. Do not submerse any electrical connectors or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

6. Spray rinse equipment with deionized, distilled, or organic-free water over the last container used.

7. Allow the equipment to air dry if time allows.

8. Record the decontamination procedure in the field book or on the appropriate form.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for IDW disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the equipment blank. The equipment blank provides information about the effectiveness of the decontamination process employed in the field. An equipment blank can detect contamination that may arise from potentially contaminated equipment or equipment that has not been decontaminated effectively.

Equipment blanks consist of a sample of analyte-free (i.e., deionized, distilled, organic-free) water that is poured over and through a decontaminated sampling device and placed in a clean sample container. Ideally, the reagent water should come from the laboratory and be certified as clean. If the blank water is not certified as clean and/or not supplied by the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should also be sent to the laboratory for analysis.

Equipment blanks are typically collected for all parameters of interest at a minimum rate of 1 per 20 samples for each parameter. The frequency of equipment blank collection will vary from project to project, depending upon the data quality objectives, and will be specified in either the site-specific sampling plan or QAPP. Equipment blanks are typically not required if dedicated sampling equipment is used.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or on the appropriate form. Any deviations from the decontamination procedures specified in the sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field book. Refer to RMD SOP 001 for field documentation procedures.

6.0 REFERENCES

USEPA. December 1987. *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001.

USEPA. January 1991. *Compendium of ERT Groundwater Sampling Procedures*. OSWER Directive 9360.4-06. PB91-9211275.

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. January 1999. *Compendium of ERT Groundwater Sampling Procedures*. EPA/540/P-91/007. OSWER Directive 9360.4-06. PB91-921275.

USEPA. December 20, 2011. *Field Equipment Cleaning and Decontamination*. SESDPROC-205-R2. Region 4. Science and Ecosystems Support Division. Athens, Georgia.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
1	DECEMBER 2016	ADDED ATTACHMENT B TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

Attachment A: SOP Fact Sheet

EQUIPMENT DECONTAMINATION

PURPOSE AND OBJECTIVE

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

WHAT TO BRING

- Field book
- Appropriate PPE
- Site-specific HASP
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate
- Potable water (or water containers if potable water source on site or nearby)
- Pump or pressure sprayer
- Squeeze bottles filled with appropriate decontamination chemicals (e.g., organic solvents, nitric acid)
- Containers, such as buckets or wash basins (type and number is dependent on the procedure)
- Scrub brushes
- Aluminum foil
- Polyethylene sheeting

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the latest version.
- Review site-specific sampling plan/QAPP for decontamination procedures and procedures for management of investigation-derived waste (IDW) (e.g., used decontamination solutions).
- Confirm all required decontamination supplies are in stock or order as needed.

ON-SITE

- Verify project HASP including safety data sheets for decontamination chemicals used on site.
- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Establish a designated equipment and personnel decontamination area.
- Provide for the proper collection and management of all IDW.
- Verify that appropriate PPE is worn by all site personnel (including subcontractors) and the work area is safe.

SAMPLING EQUIPMENT DECONTAMINATION - PROCEDURES

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. **A more simplified procedure for decontamination of measuring equipment is presented in the SOP.** Note: The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor and the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. The decontamination line should progress from "dirty" to "clean".
   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.
2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container.
3. Brush any visible dirt off of the sampling equipment before getting equipment wet.
4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container.

EQUIPMENT DECONTAMINATION

5. Rinse the equipment with potable water over an appropriate container. If an additional acid or solvent rinse is not required, proceed to Step 8.
6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.
7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Caution and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.
   Allow the equipment to completely air dry prior to proceeding to the next step.
   ** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.
8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water.
9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container).
   *NOTE that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field logbook or on the appropriate form.
10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.
11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

INVESTIGATION DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or an appropriate field form. Any deviations from the decontamination procedures specified in the work plan, sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field logbook. Refer to RMD SOP 001 for field documentation procedures.

DOs AND DO NOTs OF EQUIPMENT DECONTAMINATION

DOs:

- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them on site work.
- DO manage and collect IDW in accordance with project requirements.
- DO use deionized, distilled or analyte free water that is provided by the laboratory, is certified analyte-free, and/or meets project requirements.
- DO use sufficient amount of decontamination fluids so that the fluid flows over the equipment and runs off.
- DO use new wrapped disposable dedicated sampling equipment when appropriate to minimize the need for decontamination.

DO NOTs:

- DO NOT use an excessive amount of soap during decontamination.
- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc.; call PM if this issue arises.

Attachment B: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Equipment Decontamination Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Use only Alconox® or Liquinox® soap; do not use Decon 90. • Use new plastic buckets for wash and rinse water. • Ensure that PFAS-free water is used during the decontamination procedure. • Do not use aluminum foil.
1.5	Always consult the Site-specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to decontamination procedures: • Tyvek® suits should not be worn. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Food and drink should not be allowed within the decontamination area. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with decontamination should wear a new pair of nitrile gloves after each decontamination procedure when handling equipment to avoid re-contamination. Avoid handling unnecessary items with nitrile gloves. • Do not store on or cover equipment with aluminum foil after decontamination. Use of polyethylene sheeting is acceptable. • Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended six washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work.
2.2	• New nylon or metal bristle brushes should be used for mechanical cleaning methods. • If high-pressure water is used, it must be tested prior to use for presence of PFAS.
2.3	• Ensure that PFAS-free water is used during the decontamination procedure.
2.4	• Ensure that PFAS-free water is used during the decontamination procedure.

Title:	Procedure Number:
Packaging and Shipping of Non-Hazardous Environmental Samples	**SOP Fact Sheet ECR 023**
	Revision Number: **0**
	Effective Date: **January 2018**

Darby Litz		Elizabeth Denly	
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Darby Litz	01/11/18	Elizabeth Denly	01/11/18

SOP FACT SHEET

PACKAGING AND SHIPPING OF NON-HAZARDOUS ENVIRONMENTAL SAMPLES

Purpose and Objective

This fact sheet has been developed to guide TRC personnel in the methods for proper packaging and shipping of non-hazardous environmental samples. In general, non-hazardous environmental samples include drinking water, groundwater, ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with regulated levels of hazardous materials (dangerous goods). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as hazardous materials (see below). Please note that packaging of vapor and air samples is not included in this SOP Fact Sheet. Proper packaging and shipping of samples is important for maintaining sample integrity and ensuring prompt and reliable shipment of the samples to the analytical laboratory, as well as protecting the health and safety of the field, shipping, and laboratory personnel.

This Fact Sheet **does not address the shipment of hazardous materials**, as the shipping of hazardous materials requires specialized packaging, labeling, shipping, and training/certification. **Note**: According to the United States Department of Transportation, “the Secretary shall designate material (including an explosive, radioactive material, infectious substance, flammable or combustible liquid, solid, or gas, toxic, oxidizing, or corrosive material, and compressed gas) or a group or class of material as hazardous when the Secretary determines that transporting the material in commerce in a particular amount and form may pose an unreasonable risk to health and safety or property” 49 U.S.C 5103(a). If the composition and properties of a waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport. In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., nitric acid [HNO_3], sodium hydroxide [NaOH] pellets, hydrochloric acid [HCl], Methanol, etc.), which are designated as dangerous goods by the International Air Transport Association (IATA), is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance. Dangerous goods must not be offered for air transport by any personnel except personnel trained and certified by IATA in dangerous goods shipment. Contact the laboratory if you are unsure if your material is regulated or need assistance in shipping or transporting samples**.**

What to Bring (some or all of these may apply)

- Appropriate level of personal protection in accordance with the Site Health and Safety Plan
- Coolers with return address of TRC office written on inside of lid or coolers provided by laboratory
- Heavy-duty plastic bags and/or trash bags
- Plastic Ziploc® bags, small and large
- Fiberglass-reinforced packing tape or strapping tape is preferred, or clear packing tape or duct tape
- Packing materials, such as foam peanuts and/or Bubble Wrap®

- Ice (Blue ice not recommended)
- Custody seals
- Chain-of-custody forms
- Landing pad (can be purchased from Federal Express; see Attachment)
- Tie-on tags (can be purchased from Federal Express; see Attachment)
- Shipping labels and documents (*e.g.*, air bill)
- Pens and markers, preferably waterproof
- Zip ties
- Clear tape
- Cooler labels (“Keep Refrigerated/Cool”, “THIS END UP”, “FRAGILE”, “Saturday delivery”, arrow labels, etc.)
- Laboratory-prepared temperature blank

On-site Procedures

- Use a sturdy cooler in good condition. Secure and tape drain plug (inside and outside), if present, with fiberglass-reinforced packing tape or duct tape.
- Line the cooler with a large heavy-duty plastic/trash bag.
- Verify that all caps on bottles are tight (will not leak).
- Verify sample labels and chain-of-custody records are completed properly.
- Pack samples with sufficient padding and ice to remain intact during shipment and at proper preservation temperature.
- If glass bottles are being shipped, place a layer of shock-absorbent material, such as Bubble Wrap®, on the base of the cooler to protect against breakage during shipping. Additionally, considered placing shock-absorbent material between the sample containers and the cooler sidewalls.
- Consider placing all bottles in separate and appropriately sized plastic Ziploc® bags or Bubble Wrap® bags provided by the laboratory. Up to three volatile organic analysis (VOA) vials may be packed in one Bubble Wrap® bag (from the same sample point). All glass bottles should be wrapped in Bubble Wrap®; all sample bottles should be placed in the cooler in a vertical position to minimize potential leaks and cross-contamination.
- Verify appropriate trip blanks (for volatile organic compound [VOC] analyses) and temperature blanks are included in the sample cooler in accordance with project-specific requirements. If multiple coolers prepared for one project, keep VOC samples in the same cooler to minimize the number of trip blanks submitted for analysis.
- Place ice in cooler. A plastic bag should be used as a moisture barrier between the ice and sample bottle labels to protect label integrity. This can be accomplished by placing loose ice around sealed Ziploc® bags containing sample bottles or by sealing ice in large plastic Ziploc® bags or trash bags and placing around the sample containers. Ice should be below, in between, and on top of samples within the large heavy-duty plastic/trash bag. **NOTE:** It is recommended that at least one-third of the cooler volume should be filled with ice.

- Fill the remaining space in cooler with shock-absorbent material, such as sheets of Bubble Wrap®. Keep in mind that the sample containers are less likely to break if their movement is minimized during shipment.
- Place the completed chain-of-custody record for the laboratory in a plastic Ziploc® bag. Tape the bag to the inner side of the cooler's lid. **NOTE:** If laboratory courier service is used, the chain-of-custody record may be handed to the courier and not be put inside the cooler; the courier must sign the record upon receiving the samples. Alternately, you can treat the laboratory courier just as you would a common carrier like Federal Express. In this situation, the chain-of-custody gets signed at the laboratory upon receipt.
- The sampler should keep a copy of the completed and signed chain-of-custody record.
- Wrap cooler at least two times with fiberglass-reinforced packing tape (preferred) or duct tape at each end of the cooler.
- Custody seals should be placed on the opening of the cooler. **NOTE:** Custody seals are not required when laboratory courier service is used, as long as the courier signs the chain-of-custody document as noted above. Consider applying custody seals even on hand-delivered or couriered coolers to avoid potential confusion. Cover the custody seal with clear packing tape that extends around the entire cooler and overlaps itself so that it cannot be easily removed without breaking the seal. In some situations, it may be appropriate to install two (or more) custody seals, one at each end, placed diagonally opposite from one another. The custody seals should be placed such that the cooler cannot be opened without destroying at least one of the labels.
- Use a "THIS END UP" label or arrow labels to indicate proper upward position of the container.
- Add a label containing name and address of both the shipper and the recipient on the outside of the container. Use Federal Express tie-on tags, if applicable, attached with zip ties to affix the label to the cooler handle if possible.

<u>Shipping</u>

- Consider using prepaid shipping labels supplied by the laboratory, if possible.
- Determine ahead of time the location and deadline for when samples must be available for courier pickup or at the shipper to ensure the samples go out on time.
- Ship the sample using an appropriate method, typically overnight or same day, to arrive by the required time. Samples shipped on Friday for Saturday delivery must be coordinated ahead of time to verify laboratory staff are available to receive the samples on weekends. Liberally apply "Saturday Delivery" stickers to the outside of the cooler. Verify that the common carrier marks the cooler and shipping documents appropriately for Saturday or Sunday delivery.
- Check the laboratory sample tracking for acknowledgment of receipt of container and arrival of shipment.

Additional Guidelines when Using Federal Express

A. Shipping Coolers with Environmental Samples by Federal Express (FedEx)

TRC has experienced some issues with coolers not getting to their destination because of lost labels and this has resulted in the recollection of samples. Shipping of coolers presents a unique problem. It is important that the contents of coolers arrive at the laboratory in a timely manner, but sometimes, despite best efforts, the shipping labels come off of the coolers because they do not adhere well. This may cause delays and/or non-delivery of the coolers, resulting in samples that are no longer available or not appropriate for analysis because of temperature and/or holding time requirements.

At the advice of FedEx, it is strongly recommended that every time a cooler is shipped, that **two** different types of labels be used on the cooler:

1. A "landing pad" (FedEx #156841): A "landing pad" is a super sticky label that is adhered directly to the top of the cooler. The barcode label then gets put on top of the landing pad. These landing pads are designed specifically for use with odd-shaped or non-smooth surfaces.
2. A "tie-on tag" (FedEx #150454 large tag, or #149849 for small tag): Along with the landing pad and label, it was recommended to also use a tie-on tag if there is a handle on the cooler. The tie-on tag wraps around the handle of the cooler and then sticks to itself. The barcode label then gets adhered to the longer side of the tie-on tag. For added strength, a zip-tie should also be used to secure the tie-on tag to the handle.

Both the landing pads and the tie-on tags can be ordered by calling 800.GoFedEx and referring to the FedEx #s above. In addition:

1. TRC staff should place these labels on the coolers, rather than having FedEx place them.
2. TRC staff should place a "Keep Refrigerated/Cool" label on the cooler, which may be helpful to keep the shipment moving.
3. The use of laboratory courier service, when available, rather than FedEx, is suggested.

B. Insuring Sample Shipments

FedEx does NOT insure sample shipments; meaning if the shipment is lost or delayed, FedEx will not pay for the cost to recollect the samples.

What FedEx does offer is a Declared Value; however, again this does not cover the cost to recollect the samples. Therefore, do **NOT** pay the extra fee for a Declared Value when shipping a cooler of samples; it is a waste of money.

What may be available is that TRC's insurance program may cover losses in excess of $10,000. If you have an incident that meets these criteria, you should notify your manager, Greg Hobbs and Andrew Johnson/TRC legal for any loss you believe exceeds $10,000. TRC legal can address the merits of an insurance claim at that point in time.

C. Insuring Equipment Shipments

When shipping equipment (e.g., a GPS unit), the following is suggested:

1. Using FedEx's Declared Value option **DOES** make sense when shipping valuable equipment. Currently FedEx's cost for this option is $3 for shipments valued between $100 to $300, and $1 per $100 of declared value for shipments in excess of $300. The cost of insuring equipment should be factored into the cost of the project.
2. If the equipment does not have its own specialized shipping container (e.g., pelican case), then request that FedEx package the equipment for shipment. If FedEx provides the packaging, and the equipment is damaged, then FedEx is responsible. If TRC packages the equipment, then experience has shown that FedEx will deny the claim, even if a Declared Value was used, because FedEx will claim that it was improperly packaged.

Monitoring Well Installation Procedures

Title: **Groundwater Monitoring Well Installation**	Procedure Number: **RMD 007**
	Revision Number: **0**
	Effective Date: **January 2014**

Authorization Signatures

Technical Reviewer James Peronto	Date 1/14/14	Remediation Practice Quality Coordinator Elizabeth Denly	Date 1/14/14

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ATTACHMENTS

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the construction and installation of groundwater monitoring wells. TRC typically employs a drilling subcontractor to perform the actual construction and installation. The SOP conforms to *A Compendium of Superfund Field Operations Methods* (EPA/540/P-87/001) and American Society for Testing and Materials (ASTM) standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004). A thorough discussion of well design, installation, materials, and potential problems is found in *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring,* Chapter 10: Design and Installation of Ground-Water Monitoring Wells (Nielsen and Schalla 2006). In general, this SOP conforms to typical practices utilized in the field; project-specific and local or state regulatory requirements should be applied, as needed.

1.1 Scope and Applicability

The objective of a groundwater monitoring well is to provide for the collection of representative groundwater samples and hydrologic data on the target saturated zone. These objectives require that the well be installed and developed (well development is presented in RMD SOP 006) using suitable materials, equipment, and procedures that will best represent the actual hydraulic conditions. Specific monitoring well design and installation procedures depend on project-specific objectives and subsurface conditions. The well construction activity should include consideration of the potential impact on the groundwater quality and measures to rectify that impact to the extent practicable. The following aspects should to be considered prior to well installation:

- Borehole drilling method
- Well construction materials
- Well depth
- Screen length
- Location, thickness, and composition of annular seals
- Well completion and protection requirements

Monitoring well installation will be performed in accordance with the applicable regulatory agency standards and the project-specific work plan. Drilling methods used to pilot the borehole for monitoring well installation will be dependent on the physical nature of the subsurface materials (unconsolidated materials and/or consolidated materials) at the project site.

1.2 Summary of Method

The most common type of monitoring well installations are single-screen, single casing wells designed to monitor one specific interval within the groundwater. Monitoring wells are typically 2 inches (inside) diameter, but may be larger or smaller depending on the project requirements. With direct push technology being used more frequently, 1-inch diameter wells are also frequently used. Monitoring wells most commonly consist of 5 or 10 feet of well screen with an interconnected length of blank well casing that extends to the surface. The annulus between the screen and the formation is filled with a filter pack of appropriately-sized sand depending on the formation material. The annulus between the blank casing and the borehole is filled with an annular seal to the ground surface. A surface completion usually consisting of a traffic-rated well vault or monument that protects the well from damage or unauthorized use is installed at or above the surface.

For more complicated monitoring well installations, such as situations requiring very small screen intervals (such as with fractured rock), open boreholes, or multiple zones of interest, the well design can be modified to suit the application. See Nielsen and Schalla (2006) for additional information on less conventional well installations.

In general, all well materials (other than filter sand, seals, and grout) are typically provided by the manufacturer and are individually plastic-wrapped. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

1.3 Equipment

The following list of equipment may be used during the installation of groundwater monitoring wells. Many of these materials may be supplied by the drilling subcontractor. Specific details on these materials are described in Section 2.2. Site-specific conditions may warrant the use of additional items or deletion of items from the list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Weighted tape measure appropriate to the depth of well
- Well screens with appropriately sized slot openings
- Well casings/risers
- Well end caps
- Centralizers
- Graded sand for filter pack (appropriate for formation and screen slot size)
- Fine-grained sand (for use between filter pack and annular seal)
- Bentonite pellets or granules/chips
- Powdered bentonite
- Type I Portland cement
- Redi-Mix concrete
- Protective surface casing (for aboveground or “stick-up” wells)
- Lockable well cover
- Steel manhole/curb box (for flush-mounted wells)
- Equipment decontamination supplies

1.4 Definitions

Annulus/annular space	The space between the well casing/screen and the borehole wall.
Annular seal	An interval of low-permeability material placed above the filter pack designed to inhibit the flow of water into or through the annulus.
Bentonite	A naturally occurring deposit of volcanic ash that has partially weathered to form an absorbent swelling clay, consisting mostly of montmorillonite.
Bridge(-ing)	An obstruction within the annulus that may prevent circulation or complete installation of annular materials.
Casing – pipe (well casing)	Rigid pipe constructed in threaded or welded sections installed to temporarily or permanently counteract caving of the borehole or to isolate an interval to be monitored.
Casing - protective	A section of larger diameter pipe placed over the uppermost end of a monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access.
Caving (sloughing)	The inflow or collapse of unconsolidated material into a borehole that occurs when the borehole walls lose their cohesive strength, or a detached section of consolidated material is dislodged into the borehole.
Cement (Portland cement)	A mixture of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce a hardened material when mixed with water. Type I Portland cement as classified by ASTM C150 Standard Specification for Portland Cement is a general purpose cement most commonly used for monitoring wells when the special properties (e.g., sulfate resistance, high early strength, low heat of hydration) specified for other types are not required.
Centralizer	A device that assists in centering the riser pipe and screen in the borehole or casing.
Filter pack (gravel pack; sand pack)	An annular material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.

Flush-threaded	Casing or riser that is threaded and sized in such a manner that the inside and outside diameters are maintained between sections and joints.
Grout	A low-permeability material placed in the annulus between the well casing or riser and the borehole wall (typical well construction), or between the riser and casing, to maintain the alignment of the casing and riser and to prevent movement of groundwater or surface water into the annular space.
Riser	Sections of blank pipe that connect to the well screen and extend to or above the ground surface.
Tamping device	A heavy object attached to a measuring tape, rope or wire used to slip inside the annular space to ensure annular materials are properly placed per the designed depth criteria and to prevent bridging.
Tremie pipe	A tube or string of piping used to convey filter pack and annular seal materials from the ground surface to fill the annulus.
Vented end cap	A covering device that slips over or into the top of the well riser with a hole drilled in it to allow continuous equilibration of the potentiometric surface with the atmospheric pressure.
Well screen	Pipe (typically polyvinyl chloride [PVC] or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing.

1.5 Health & Safety Considerations

Drilling operations can create a hazardous environment. The potential for injury is fairly high around a drill rig. Level D PPE, including a hardhat, gloves, steel-toed safety shoes, and safety glasses, must be worn at a minimum. Hearing protection is also standard for drilling personnel. Tyvek clothing is recommended when mixing grout. Most well installations are performed with the assistance of the hoist on the drill rig mast as the downhole drill pipe or augers are removed when the well materials are placed. Therefore, TRC personnel must be mindful of the same hazards that apply during drilling. TRC staff should only approach the drill rig if necessary to monitor the breathing zone, confirm depths of materials, or confer with the driller. Before approaching the drill rig, direct eye contact should be made with the driller so they are aware of your presence. The following safety requirements should be adhered to while performing drilling activities:

- The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

- Serious injuries have occurred while the driller removes casing using a cable and winch. The winch should only be used to move augers or piping – NOT to pull casing, piping or augers from the ground. Use of the drill string is the safest means to pull casing, auger, or piping as the well materials are placed.

- Exposure to potential contaminants can occur from vapors coming from the open boring and from contaminated groundwater being forced out of the boring when grouting.

- While the exposure duration is very low, the dusts from well sand, bentonite, and cement can harm the lungs. Workers should avoid the dust produced when placing the well materials.

- Cement is highly caustic and can irritate the skin. Chemical-resistant gloves should be worn if contact with cement is necessary.

- The bags of sand, cement, and bentonite typically do not require a knife to cut them open. A dull instrument, such as a screwdriver, is sufficient.

- Cutting PVC well casing or screen should be conducted using a PVC cutting tool or hacksaw.

1.6 Cautions and Potential Problems

Well installation is typically conducted by the drilling subcontractor. TRC personnel serve to observe and document the installation and to serve as quality control that the well is installed according to the project specifications. The following cautions or problems may be associated with well installation

- Wells are often specified to be installed as "water table" wells with the screen designed to intersect the top of the water table. The difficulty arises in being able to determine if the water surface as measured in the open borehole will remain the same once the well is installed.

- It is also common that "water table" conditions do not exist due to a confining layer or fractured rock environments. In such cases, the well screen is placed in the producing formation or fracture, and the screen may not intersect the potentiometric surface.

- A well screen should never be placed such that the screen straddles a confining unit, thus connecting two separate aquifer units.

- Flush-mount well constructions require appropriate design to account for vehicular traffic and potential water infiltration into the surface completion among other things. In general, wells with flush-mount completions should not be located in low-lying areas or drainage paths where water influx can be a recurring problem. Appropriate design should consider a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault can drain.

- Aquifer or other pressure conditions at some locations may warrant consideration of a vent hole in the well cap. For flush-mount well completions, a vent hole can provide a means for ambient surface water to enter the well if the if the completion is not designed properly.

Careful consideration should be given to well completion design, including vented well caps, depending on the circumstances at the location.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Monitoring well installation is typically conducted by a subcontractor experienced in such installations following completion of a soil boring. A qualified TRC representative provides oversight and documentation that the well is properly installed. Subcontractor personnel should not be on the site without a TRC representative being present unless specific prior approval has been given by TRC. The TRC representative should prepare a Monitoring Well Installation Form (Attachment A) that documents the well completion details.

2.1 Preparation

Prior to the initiation of field work, the Project Manager or field technical lead (site manager) will secure the services of a qualified drilling contractor. A contract between TRC and the drilling contractor should be executed before mobilization. At a minimum, the drilling contractor must meet the following requirements:

- have the appropriate licenses, registrations and/or certifications for drilling and monitoring well installation in the state in which the work is being conducted,
- have the proper equipment in good operating condition and free of leaks (fuel, hydraulic fluid, lubricants, and similar compounds) available to perform the type of well installation required, and
- have experienced personnel who are OSHA-trained to work on hazardous waste sites.

Before the start of field tasks, the TRC field representative is responsible for coordinating the following items with the drilling subcontractor personnel:

- familiarizing the subcontractor with the objectives of the investigation,
- providing and reviewing a copy of the project-specific work plan with the subcontractor,
- providing and reviewing a copy of the project HASP with the subcontractor,
- determining overhead hazards including power lines, buildings, trees and verifying local/city regulatory requirements if tree roots will be damaged, and
- performing a daily health and safety review with the subcontractor.

Compliance with state and federal requirements is required prior to the installation of monitoring wells. TRC is responsible for ensuring that all required permits have been obtained prior to the start of work. If state regulations require the driller to obtain drilling permits and/or utility clearance approvals, TRC personnel must review the documentation prior to the start of work. This documentation may include, but is not limited to, the following:

- notification and approval to drill/install a monitoring well (access agreement),
- registration or notification of the well installation,
- permit for water withdrawals,
- well abandonment when the project is completed, and
- applicable dig-safe permits or approvals (utility clearance).

Copies of any permits and notification forms must be provided to TRC.

2.2 Materials

Unless approved in writing by TRC, no lubricants or glue shall be used in any manner that could possibly contaminate samples, boreholes, or monitoring wells. The following provides a detailed description of the key features of well installation and how their proper selection and use is necessary to complete an effective groundwater monitoring well.

2.2.1 Well Screens

Monitoring well screens most commonly consist of two-inch diameter, flush-threaded, Schedule 40, PVC, machine-cut, slotted, wire wrap and/or V-wire screen. Up to two-inch or smaller diameter PVC is often used for wells installed using direct-push drilling methods. Four-inch diameter (and larger) wells are most typically used to accommodate larger pumps for groundwater and/or non-aqueous phase liquid (NAPL) recovery – but may also be used for groundwater monitoring. The screen slot size should be selected to retain a minimum of 90% of the filter pack material (see below). The most commonly used slot size is 0.010-inch (0.25 mm) slot openings.

In wells installed at depths greater than 100 feet, Schedule 80 PVC well screens can be used to minimize narrowing of the slots from the increased weight of the riser string. Note that the inside diameter of Schedule 80 riser pipe is slightly smaller than Schedule 40. That difference may cause difficulty when inserting some downhole monitoring equipment or instrumentation.

PVC screens can be adversely affected (typically by weakening or swelling) by concentrations of organic solvents that exceed 25% of the solubility limit. If such subsurface contaminant conditions are possible, the type and concentration of solvent should be researched in more detail prior to well installation. Stainless steel is also a common choice for well screens, but under certain conditions, metals (including iron, nickel, lead, and chromium) have been known to leach from stainless steel screens; in addition, stainless steel screens are costly. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations.

Manufactured prepacked well screens are commercially available and generally consist of a standard, slotted Schedule 40 PVC well screen pipe (typically 0.5 to 2.0 inch diameter) wrapped in a stainless steel mesh filled with filter sand (typically 20-40 grade silica sand). Additional finer sand pack is commonly added directly above the installed prepack as a grout barrier. Since the sand is packed around the slotted PVC before the well screen is installed, using prepacked screens guarantees that sand will be located directly adjacent to and uniformly around the well screen. Prepacked well screens are typically installed by direct push drilling techniques. The use of prepacked well screens generally makes well installation quicker and more efficient than traditional methods. However, their use for permanent groundwater wells for chemical groundwater quality monitoring should first be verified to determine consistency with project-specific and state regulatory requirements.

2.2.2 Riser and End Caps

Monitoring well riser and end caps will consist of appropriately sized, flush-threaded material compatible with the well screen. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations. The top cap should be vented to allow the passage of air, unless the well is to be installed at or below the ground surface (i.e., "flush mount well"). In that case, the top of the well should be sealed with an expansion cap/plug or a protective watertight manhole provided to prevent the inflow of storm water runoff into the well.

2.2.3 Filter Pack

A filter pack (also known as "sand pack" or "gravel pack") will be required in any formation other than coarse sand and gravels containing less than 10% fines (silts and clays) by weight. In such formations (i.e. well-to-moderately sorted sands and gravels), a filter pack may not be necessary and the formation can be allowed to collapse around the screen; however, most regulatory guidance requires a filter pack be constructed. The purpose of the filter pack is to inhibit transport of fine-grained formation material into the well screen and stabilize the formation so as to avoid excessive caving/sloughing during installation and development. The introduction of coarser material than the natural formation also results in increasing the effective diameter of the well.

The filter pack material shall be composed of washed, graded, commercially-produced silica sand. Based upon field estimates of grain size distribution of the screened aquifer materials, a sand pack should be selected. A detailed discussion of filter pack determination is found in Nielsen and Schalla (2006). ASTM Standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004), may also be consulted for further guidance on specifications for sand packs for various conditions. If grain size information is not known for the formation, several sand packs should be available during well construction based upon known or presumed geological information for the site. The most common choice of filter pack sand is 20-40 mesh for 0.010-inch screen slots.

One to two feet of clean, fine sand can be used (required in some states) as a buffer between the annular seal and the filter pack to provide added protection that grout invasion into the filter pack and/or the well screen will not occur. This layer is sometimes referred to as the "secondary filter pack." The sand should be well sorted quartz sand; 40-60 mesh sand is typically used for this purpose.

2.2.4 Annular Seal

An annular seal, typically a minimum of 2 feet thick, is placed above the filter pack and screen to inhibit the boring from serving as a pathway for the vertical movement of water. Without an annular seal, the wellbore annulus can serve to transport contaminants between geologic units (for example, from unconfined to confined aquifer or from the vadose zone to the groundwater). The annular seal will consist of bentonite pellets, chips, granules, or slurry (produced from powdered bentonite). Bentonite swells rapidly when in contact with water. Coated bentonite pellets are preferable in situations where the bentonite must travel through a water column greater than 30 feet, because uncoated pellets may expand and bridge the annulus above the desired depth. Larger bentonite chips may also be used since they also swell at a slower rate than pellets and granules. The selection of the form of bentonite will depend upon the location of the top of the filter pack relative to the water table. If the seal is placed in the vadose zone, the seal will be hydrated with potable water. The volume of water necessary to hydrate the bentonite chips or pellets is dependent on the pellet size, volume of pellets used, and manufacturer's requirements. Granular bentonite is the best choice in situations where the seal is placed in the vadose zone – particularly in arid climates. Other forms of bentonite require longer contact times with water to form an adequate seal. Note that if the seal may be exposed to NAPL, it can shrink and crack. In addition, in situations with total dissolved solids (TDS) concentrations >5,000 parts per million (ppm) or chloride concentrations >8,000 ppm, bentonite will not swell; in these situations, neat cement should be considered as an alternative seal.

2.2.5 Grout

In certain wells, the annular space above the bentonite seal to the ground surface may be grouted with a mixture of 95% Portland cement or equivalent, and 5% bentonite grout, mixed with potable water to the specifications of the concrete manufacturer. This equates to 6 gallons of water added to each 94-pound sack of Type I Portland cement with 3- to 8% powdered bentonite added to improve the workability of the slurry. Bentonite should be prehydrated before adding to the cement to limit clumping. Note that bentonite does not swell considerably when mixed with cement. Grout is generally mixed in a container or barrel using pumps and may include an electric paddle or rotating vane blender.

Note: Grout mixtures may vary based on applicable regulatory requirements or site-specific subsurface conditions.

2.2.6 Surface Protective Casing

The primary purpose of a protective surface completion is to prevent surface water runoff from entering the well, and to prevent unauthorized access to the well. There are two types of protective casings used for surface completions of monitoring wells: (1) the above ground completion and (2) the below ground or flush-mount manhole-type completion, which is typically used in high traffic or public areas where the well could be damaged by equipment or is deemed unsightly.

<u>Above-Ground Completion</u>

An above-grade surface completion (i.e., a well monument) consists of rigid surface casing (typically galvanized or steel coated with rust-proofing or anodized aluminum). The inside diameter of the casing should be at least 2 inches larger than the well casing and be long enough to extend 2.5 to 3 feet above and below the ground surface. The casing is set in the annular seal and/or the surface seal that consists of either concrete (in warm to moderate climates) or bentonite (in cold climates). Bollards are often used around the aboveground surface casing to prevent vehicular damage.

The surface casing shall have a cap with provision for a lock that cannot be easily removed and leave at least 3 to 6 inches of clearance between the top of the well casing and the cap. The base of the casing, at the point where it shall extend above the concrete pad, should have a small weep hole drilled through the casing to prevent the build-up of precipitation or ice between the steel casing and well riser.

Flush-Mount Completion

Flush-mount well completions are generally selected or may be required in areas where vehicular traffic or equipment operation is an important consideration and an above-ground completion may not be a viable option. Depending on the expected activity in the area of the flush-mount completion and the existing surface conditions, the strength and durability of the completion will need to be designed appropriately. An appropriate completion may not be noticed, but a poor completion will generate negative comments with increasing wear and tear. In general, flush-mount completions should be located away from local low areas that drain or accumulate water, if at all possible.

Well completions flush with the pavement or ground surface may be accomplished by various means including the use of well can cylinders or elaborate vaults, and sufficient concrete to stabilize the structure within its surroundings. Regardless of the surface completion, the interior of the flush-mount completion should include the following characteristics: 1) rubber gasket to provide a cover seal; 2) locking capability for well security; 3) drainage management; and 4) sufficient interior space to accommodate any equipment (e.g., dedicated pump) that may be placed in the well.

Flush-mount well completions should provide a minimum of 2 inches of annular space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective steel “skirt” should extent at least 1 foot below the top of the well vault. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. Depending on location considerations, the well completion may be sloped slightly away from the well or completed truly flush with the surroundings. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault will drain.

2.3 Monitoring Well Installation

Boreholes to be completed as monitoring wells will be advanced and logged in accordance with RMD SOP 005 (Visual-Manual Procedure for Soil Description and Identification). Equipment used to advance the boring and install the monitoring well will be decontaminated prior to the start of the boring.

All downhole well construction materials (with the exception of the protective casing) should be clean prior to use at the site. In general, all well materials (other than filter sand, seals, and grout) are typically provided individually plastic-wrapped by the manufacturer. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can also be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

2.3.1 Procedures

Monitoring wells will be installed by the drilling subcontractor under the direction of a qualified TRC geologist, environmental scientist, or engineer. Monitoring wells will be installed using the following general procedures which may be dependent on the site-specific requirements.

1. Prior to mobilizing to the site, the construction details of the well to be installed will be provided to the driller, including well identifiers, locations of wells, boring diameter, well materials, screen slot size, screen lengths/depths, riser length, well depths, filter pack materials and depths, annular seal, grouting requirements, and well surface completion requirements.

2. All well materials shall be inspected to ensure that they are new and clean prior to installation.

3. Sections of screen and riser will be threaded together and lowered into the borehole to the predetermined depth. It is preferable to keep the drilling string or temporary casing in the hole while well materials are placed and slowly remove them as the well materials are installed. Centralizers may be used on the well riser in deeper wells to ensure proper well placement within the center of the borehole. Centralizers should not be placed within the location of the annular seal. Once the well is completed, the well cap should have a hole drilled in the top for venting, if possible.

4. The selected well packing materials will be introduced into the annulus in a manner so as to ensure an adequate well pack and seal. Approximately 0.5 to 1.0 foot of filter pack may be placed at the base of the boring to establish a stable base for the well materials. The thickness of each layer of well materials placed in the annulus will be measured with a weighted measurement tape and recorded to the nearest 0.10 foot. The weighted tape may also act as a tamping device to reduce bridging. Augers or casing will be removed sequentially during sand pack installation and the well will remain at the desired depth during auger or casing withdrawal.

   The primary filter pack may be placed using a rigid tremie pipe to minimize the potential for sand bridging in the annulus. The primary filter pack should extend at least 2 feet above the top of the well screened interval. One to 2 feet of fine sand as the secondary filter pack can then be placed above the primary filter pack (if required). However, the height of the filter pack may differ from that specified here due to shallow well depth limitations and project-specific work plan requirements. The secondary filter pack should not extend into a different aquifer unit as the primary filter pack. The depth of each interval of filter pack and volume of material used must be recorded on the Monitoring Well Installation Form and/or the field book.

5. The annular bentonite seal installation technique will vary with the depth of the water table. The appropriate type of bentonite will be selected to suit the objectives of the installation program. The bentonite should be poured slowly into the annular space to minimize

bridging, with periodic tamping. The volume of the annular space should be calculated and compared to the volume of bentonite used as a check to make sure bridging in the annular space has not occurred. If a tremie pipe is used for installation of the annular seal, either coated pellets or slurry should be used because bridging may occur as the bentonite swells. The preferred method of annular seal placement is by using the drilling rods or augers as a conductor casing, except in deep or difficult wells. The annular seal typically ranges from 1 to 5 feet in thickness. Annular seals in wells installed above the water table will be hydrated typically with 10 to 20 gallons (added in 5-gallon increments) of water and allowed to swell prior to the emplacement of a cement-bentonite grout mixture (if the well is to be grouted). In arid or highly permeable formations, the bentonite pellets should be allowed to swell for 1 hour. The high TDS concentration of cement grout does not act to hydrate bentonite, so it is important to allow the bentonite to hydrate fully in water. The level and volume of material(s) used for the annular seal are then recorded on the Monitoring Well Installation Form and/or the field book.

6. Once the annular seal is sufficiently hydrated, a cement-bentonite grout (or other type depending on local regulation) is placed to fill the remaining annulus of the boring. Depending on the depth of the well and water table, the grout may be tremied into the desired location from the bottom up. A side-discharge tremie is preferred so as to not disturb the annular seal. The tremie can remain near the bottom until grouting is completed. Grout requires 8 to 48 hours to set, but it does not become rigid like cement. The grout mixture (percentage of cement to bentonite) will be recorded and will be in accordance with the project-specific work plan or recommended guidance and Section 2.2.5 of this SOP. The grout will be pumped into the boring around the well materials to the surface. If necessary, after solidification of the grout and settling occurs, the grout may need to be topped off with additional grout mixture. The need for additional grout will be based on the intended surface completion for the well. The composition and volume of material(s) used for the grout are then recorded on the Monitoring Well Installation Form and/or the field book.

7. For wells finished above-grade, the protective casing may be cemented in place as described in Section 2.2.6 or completed with grout and bentonite in areas subject to frost heave. The protective casing should be in a plumb position and installed with at least half of the casing below ground and below the frost line (3- to 5 feet below ground surface). The protective casing should have a granular material placed in the base and a weep hole drilled through the casing to allow drainage of water that accumulates in the protective casing. Once completed, the well will be locked and typically allowed to settle for a minimum of 24 hours prior to well development. After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours).

   In some instances, a concrete pad is often constructed around wells to provide a working surface and more significant protective surface seal; this concrete pad is required by law in some states. These pads should be a minimum of 4 inches in thickness and are typically a minimum of 2 feet by 2 feet. It is recommended that the concrete pad extend 4 to 6 inches below the ground surface within six inches of the borehole. In areas of traffic or periodic mowing, three or four guard posts ("bumper guards" or bollards) may be positioned around the well to protect the well from equipment. The ground or pad around the well head should be sloped away from the well to promote drainage away from the surface completion. The guard posts consist of 3- to 4-inch diameter steel pipes set 3 to 4 feet outside the concrete pad. The pipes are set at least 3 feet in the ground and are filled with concrete. The well "stickup" and the guard posts should be painted a bright color (typically "safety yellow") for visibility. The type and details of the surface completion should be sketched, photographed or otherwise recorded on the Monitoring Well Installation Form and/or the field book.

8. Depending on the location of the well, flush-mounted utility boxes (i.e., well vaults or manholes) or above-ground, steel, protective casings with locking caps will be used to complete the well. Flush-mount wells should be located outside of areas that accumulate ponded water or areas of runoff, if at all possible, to minimize the potential for well damage by freeze/thaw conditions or for surface water to flow into the completed well.

   The well top should extend a minimum of 4 inches from the bottom of the cement or grout base with sufficient distance to the vault cover to accommodate any equipment (e.g., dedicated pump) that may be placed in the well. The well vault should also include a rubber gasket to make it water tight and is typically tightened with lug bolts.

   Flush-mount well vaults should provide a minimum of 2 inches of free space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective, steel "skirt" should extent at least 1 foot below the top of the well vault. The vault will be sealed in concrete or cement grout that extends 4 to 6 inches away from the vault and extends a minimum of 1 foot below the frost depth. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. The vault should be set slightly higher than the existing grade and the concrete sloped (1- to 2% slope) away from the manhole to promote drainage away from the well. In cold-weather areas where snow removal occurs, the well may have to be set flush with the pavement to avoid damage. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole, so water that accumulates in the vault will drain. Below-grade wells should be fitted with a locking, water-tight friction cap or expandable plug because below-grade wells often fill with water.

9. The wells should be permanently marked with the well identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized. Keyed-alike weatherproof brass padlocks should be installed on each well casing.

10. The manufacturer, type, weight, and number of bags or other containers of each type of well sand, cement, bentonite, and any other grout materials should be counted and documented on the Monitoring Well Installation Form and/or the field book as a means of determining if the amount used is consistent with the information obtained by the drilling subcontractor.

11. All information concerning well installation details will be recorded on a Monitoring Well Installation Form (examples provided in Attachment A).

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

There are minimal wastes other than general refuse and PPE that is generated during well installation. Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following quality assurance/quality control procedures apply:

- Check well construction materials to ensure these materials conform with the project-specific work plan and project specifications.
- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency, if utilized.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record well installation measurements on field forms or in a field book. See Attachment A for an example of a Monitoring Well Installation Form.

The following additional information should be recorded in the field book and/or Monitoring Well Installation Form:

- Well/piezometer or monitoring point identification number
- Well permit number (if applicable)
- Date of well installation
- Type of drilling method used and model number of rig
- Ground surface elevation (if known)
- Diameter and depth of borehole
- Depth of well bottom
- Depth of top and bottom of screened interval
- Depth of top and bottom of filter pack
- Depth of top and bottom of secondary filter pack (if used)
- Depth of top and bottom of annular seal
- Depth of top and bottom of grout seal
- Type, diameter, length, and screen slot size of well screen
- Type, diameter and length of riser
- Type, diameter, and length of casing (if used)
- Type, gradation, and volume/mass of filter pack
- Type and volume/mass of secondary filter pack (if used)
- Method used for filter pack placement

- Well lock type (i.e., padlock) and key number
- Type and volume of bentonite or other material used for annular seal
- Method used for annular seal placement
- Type, volume, and mix percentages of grout used
- Method used for grout placement
- Source of water used
- Type and length of protective casing
- Type and dimensions of well vault
- Type, number and array of protective posts (if used)
- Type and dimensions of surface completion/seal
- Measurement of "stickup" above or below ground
- Initial depth to groundwater
- Other pertinent observations
- Measurement equipment used
- Decontamination procedures used

6.0 REFERENCES

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7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2014	NOT APPLICABLE

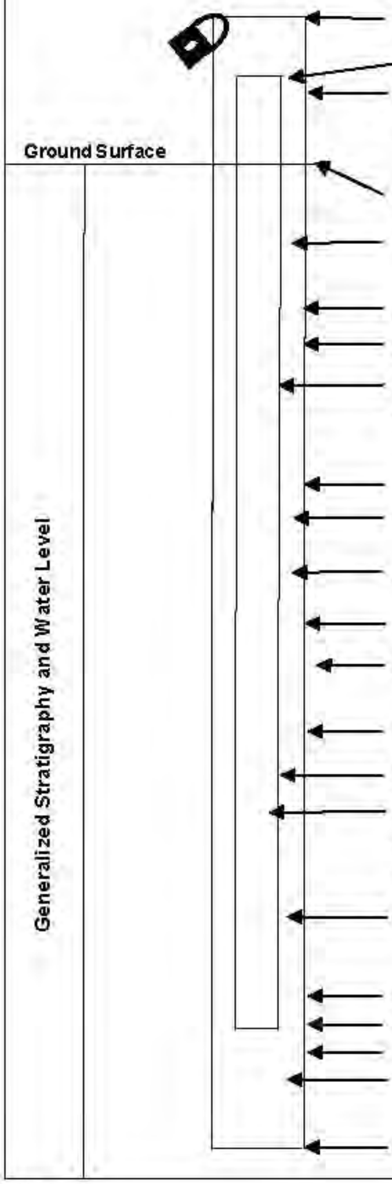
ATTACHMENT A
EXAMPLE MONITORING WELL INSTALLATION FORMS

Monitoring Well Construction Summary

Well ID.

Project: ______________ No.: ______________
Client: ______________ Date Completed: ______________
Location: ______________
Boring Contractor: ______________ Method: ______________
TRC Geologist: ______________

Depth to Ground Water: ______________
Development Date: ______________
Development Method: ______________
Notes:



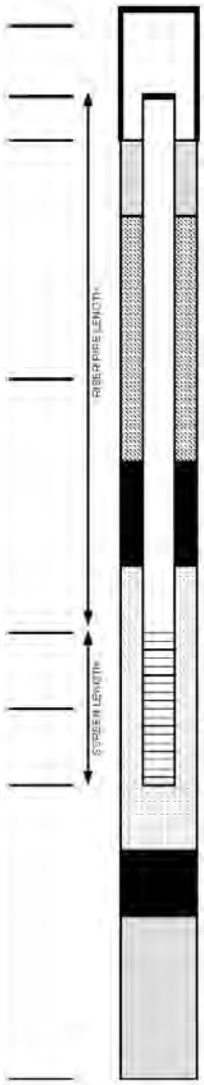
	Height/Depth ( )	Elevation ( )
Top of protective casing:	______	______
Top of riser pipe:	______	______
I.D. of protective casing: ______		
Type of protective casing: ______		
Ground Surface Elevation:	______	______
Type/thickness of surface seal: ______		
Bottom of protective casing	______	______
Borehole diameter: ______		
Riser pipe I.D.: ______		
Type of riser pipe: ______		
Top of grout:	______	______
Type of grout/backfill: ______		
Method of grout/backfill: ______		
Top of seal:	______	______
Type and thickness of seal: ______		
Top of filter pack:	______	______
Elevation/Depth top of screen:	______	______
Type of screen: ______		
Slot size: ______		
I.D. of screen: ______		
Type of filter/sand pack: ______		
Bottom of screen:	______	______
Bottom of well:	______	______
Bottom of filter pack:	______	______
Type of backfill below monitoring well: ______		
Bottom of borehole:	______	______

AF-374 November 2013

TRC WELL CONSTRUCTION DIAGRAM (FLUSH-MOUNT)

PROJ. NAME:		WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:	CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



0.0 GROUND SURFACE

TOP OF CASING

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________

PIPE SCHEDULE: ____________

PIPE JOINTS: ____________

SCREEN TYPE: ____________

SCR. SLOT SIZE: ______

BOREHOLE DIAMETER: _____ IN. FROM _____ TO _____ FT.
_____ IN. FROM _____ TO _____ FT.

SURF. CASING DIAMETER: _____ IN. FROM _____ TO _____ FT.
_____ IN. FROM _____ TO _____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________

TIME DEVELOPING: ______ HOURS

WATER REMOVED: ______ GALLONS

WATER ADDED: ______ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________

COLOR BEFORE: ____________

CLARITY AFTER: ____________

COLOR AFTER: ____________

ODOR (IF PRESENT): ____________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

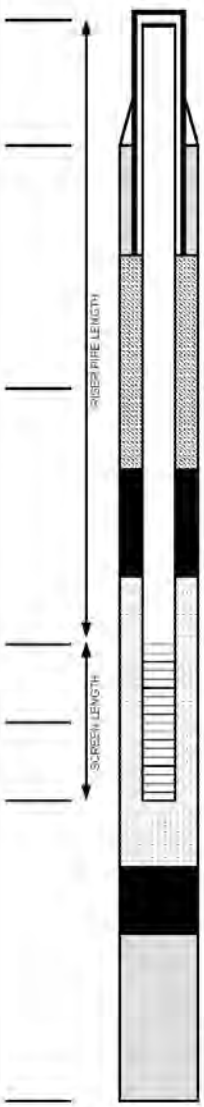
LOCK KEY NUMBER: ________

REVISED 11/2013

TRC WELL CONSTRUCTION DIAGRAM (ABOVE-GRADE)

PROJ. NAME:			WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:		CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)
____	____ TOP OF CASING
____	0.0 GROUND SURFACE
	SURFACE SEAL MATERIAL ____
	____ SURFACE SEAL
	GROUT/BACKFILL MATERIAL ____
____	GROUT/BACKFILL METHOD ____
	____ GROUT
	BENTONITE SEAL MATERIAL ____
	____ BENTONITE SEAL
____	____ TOP OF SCREEN
____	FILTER PACK MATERIAL ____
____	____ BOTTOM OF SCREEN
	____ BOTTOM OF FILTER PACK
	____ BENTONITE PLUG
	BACKFILL MATERIAL ____
____	____ HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________

PIPE SCHEDULE: ____________

PIPE JOINTS: ____________

SCREEN TYPE: ____________

SCR. SLOT SIZE: ______

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________

TIME DEVELOPING: ____ HOURS

WATER REMOVED: ____ GALLONS

WATER ADDED: ____ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________

COLOR BEFORE: ____________

CLARITY AFTER: ____________

COLOR AFTER: ____________

ODOR (IF PRESENT): ____________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

LOCK KEY NUMBER: ____________

REVISED 11/2013

ATTACHMENT B
SOP FACT SHEET

GROUNDWATER MONITORING WELL INSTALLATION

Purpose and Objective

The objective of a groundwater monitoring well is to provide for the collection of representative groundwater samples and hydrologic data at the target saturated zone. These objectives require that the well be installed and developed (well development is presented in RMD SOP 006) using suitable materials, equipment, and procedures that will best represent the actual hydraulic conditions.

What to Bring

- Personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Weighted tape measure
- Equipment decontamination supplies

Office Preparation

The TRC field representative is responsible for coordinating the following items with the drilling subcontractor personnel:

- Providing and reviewing a copy of the project-specific work plan and HASP.
- Verifying that buried utility clearance notifications/approvals have been completed. Obtain notification date and number.
- Verifying that all required permits have been obtained prior to the start of work.
- Copies of any permits and notification forms must be obtained by TRC.

On-Site Preparation

- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Verify that underground utilities have been marked out and that the mark outs are clear. Identify if any overhead obstructions or limited access areas exist near proposed borings.
- Verify that appropriate PPE is worn by all personnel and work area is safe (e.g., utilize traffic cones; minimize interference with on-site activities etc.).

General Monitoring Well Installation Procedures

Monitoring wells shall be installed by a drilling subcontractor under the direction of a qualified TRC geologist, environmental scientist, or engineer. The TRC representative should prepare a written record of the monitoring well installation. Monitoring wells will be installed using the general procedures presented in the SOP and any site-specific work plan which may be dependent on the site- or location-specific requirements. A summary of various acceptable well construction materials is presented in the SOP. The following summarizes several key aspects of monitoring well installation procedures.

- All well materials shall be inspected to ensure that they are new and clean prior to installation.
- Once the well is completed, the well cap should have a hole drilled in the top for venting, if possible.
- The thickness of each layer of well materials placed in the well annulus should be measured with a weighted measurement tape and recorded to the nearest 0.10 foot.
- The appropriate type of bentonite seal should be selected to suit the objectives of the installation program.
- The bentonite seal material should be poured slowly into the annular well space to minimize bridging, with periodic tamping. The volume of the annular space should be calculated and compared to the volume of bentonite used as a check to make sure bridging in the annular space has not occurred. If a tremie pipe is used for installation of the annular seal, either coated pellets or slurry should be used because bridging may occur as the bentonite swells.
- Grout mixtures may vary based on applicable regulatory requirements or site-specific subsurface conditions. Depending on the depth of the well and water table, the grout may be tremied into the desired location from the bottom up. Grout requires 8 to 48 hours to set, but it does not become rigid like cement.

GROUNDWATER MONITORING WELL INSTALLATION

- The ground or pad around the well head should be sloped away from the well to promote drainage away from the surface completion.
- Flush-mount wells should be located outside of areas that accumulate ponded water or areas of runoff, if at all possible, or constructed to minimize the potential for well damage by freeze/thaw conditions or for surface water to flow into the completed well.
- Completed wells should be permanently marked with the well identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized. Keyed-alike weatherproof brass padlocks should be installed on each well casing.
- All information concerning well installation details should be recorded on a Monitoring Well Installation Form (examples provided in Attachment A of SOP).

WASTE DISPOSAL

There are minimal wastes other than general refuse and PPE that are generated during well installation. Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

DATA MANAGEMENT AND RECORDS MANAGEMENT

Record well installation measurements on field forms or in a field book. See Attachment A of the SOP for an example of a Monitoring Well Installation Form.

DOS AND DO NOTS OF MONITORING WELL INSTALLATION

DOs:

- DO have the following items when going into the field:
  - Site-specific work plan
  - Site-specific HASP
  - PPE (e.g., steel-toed safety boots, hard hat, gloves)
  - Field book and indelible black ink, ball-point pens or markers
- DO review existing soil boring logs, groundwater contour maps, or geologic cross sections, if available.
- DO have the telephone numbers for the driller, testing laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them.
- DO check well construction materials to ensure the materials conform with the work plan and project specifications.
- DO inspect all well materials to ensure that they are new and clean prior to installation.
- DO document the manufacturer, type, weight, and number of bags or other containers of each type of well sand, cement, bentonite, and any other well materials used.
- DO make sure that the wells are permanently marked with a well identification number.
- DO make sure the completed well cover is securely locked.
- DO mark the location on the top of the well casing from which water level measurements are obtained following well completion.

DO NOTs:

- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc; call the Project Manager if there is an issue.
-

Title: **Well Development**	Procedure Number: **ECR 006**
	Revision Number: **1**
	Effective Date: **August 2017**

Authorization Signatures

Elizabeth P. Schwartz	Elizabeth Denly
Technical Reviewer Date Elizabeth Schwartz, PG 8/1/17	ECR Practice Quality Coordinator Date Elizabeth Denly, ASQ CMQ/OE 8/1/17

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for the development of wells. Well development is completed to (1) evacuate any water added during the drilling of wells, (2) establish a good hydraulic connection between the well and the surrounding water-bearing zone, (3) settle the sand pack and formation following the disruptive drilling and installation activities, (4) alleviate clogging, smearing or compaction of formation materials at the borehole wall due to the drilling process, and (5) remove fine particles (e.g., silt or clay) from the water column and sand pack in order to obtain groundwater samples that are representative of the water-bearing zone in which the well is installed and/or enhance groundwater extraction and injection rates. Well development typically occurs for all newly installed wells and can also be implemented to refurbish an older well where significant silt/sediment build-up has occurred, as may be observed when the measured depth to bottom of a well is notably shallower than the recorded constructed depth to bottom.

1.2 Summary of Method

Proper well development includes initial and ongoing water-level and water quality measurements, implementation of the development method, management of the development wastes, equipment decontamination, and documentation. First, the well should be opened and initial measurements (e.g., headspace air monitoring readings, depth to water, total depth of the well) are collected and recorded. The well is developed using the method selected for each project based on the lithology, site conditions, and objectives and requirements of the project. Development of the well continues until the water is visually clear and free of sediments (e.g., turbidity <10 nephelometric turbidity units [NTU]), until a minimum number of well volumes has been evacuated (depending on regulatory requirements) or until water quality parameters such as pH, temperature, and specific conductivity stabilize, depending on project requirements. All purge water is containerized for proper characterization and disposal at an appropriate facility unless prior approval to discharge to land surface has been obtained from appropriate sources (e.g., governing regulatory agency). Final measurements (e.g., depth to water, total depth of the well, total water removed) are recorded in the field book or on the Well Development Form (Attachment A). Equipment is decontaminated, as appropriate, prior to use in the next well.

After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours). In addition, more vigorous well development methods (e.g., surging) may require a relatively longer setup time before development. If a less vigorous method (e.g., bailing) is being used, development may be initiated shortly after installation when grout is not used in well installation or if the sealant is above the water table. Regardless, the method used for development should not interfere with the setting of the well seal, which should be considered in preparing the work plan.

Well development also provides an opportunity to collect data that can be used to estimate the hydraulic conductivity (permeability) of the screened water-bearing formation. These estimates can be used to estimate groundwater flow velocities, and are often needed to project the extent of plume migration, estimate monitored natural attenuation rates, and other investigative tasks. Estimates of hydraulic conductivity and aquifer transmissivity can be derived from a measure of a well's specific capacity; i.e., flow rate divided by water-level drawdown (expressed in gallons per minute per foot [gpm/ft] of drawdown). The data needed to estimate specific capacity are the flow rate (purge rate during development, measured with a flow meter or a 5-gallon bucket and stopwatch), the static (pre-pumping) depth to water, and the pumping depth to water. The duration of pumping when the pumping depth to water is measured should also be noted.

Several development methods may be used depending on site conditions and project requirements. There are several regulatory agency guidance documents (e.g., USGS, 1997) as well as ASTM standards available for reference. If possible, select a development method that avoids introduction of air, foreign water, or chemicals to the aquifer during development. A few development methods are outlined in Section 2.0. For specialized well development programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment C for further details.

1.3 Equipment

The following list of equipment may be utilized during the development of wells. Site-specific conditions may warrant the use of additional items or deletion of items from this list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and forms
- Well keys
- Socket wrench
- Centrifugal or submersible pump and tubing/hosing
- Water quality meter (including parameters such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP) and dissolved oxygen (DO)
- Flow-through cell
- Turbidity meter
- Plastic beaker, jar, or disposable plastic cups
- Bailer and cord
- Large-capacity DOT-approved containers (if required)
- Five-gallon buckets
- Surge block
- Bulk supply of deionized/organic-free water
- Well construction diagrams and previous well development data (if available)
- Equipment decontamination supplies

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and, therefore, floats on the surface of the water.
Monitoring Well	A well made from a polyvinyl chloride (PVC) pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Separate-phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Surge Block	A disc-shaped or cylindrical device that closely fits the well casing interior and is operated like a plunger below the water table to force water in and out of the well as a well development tool.

Total Depth of Well	Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

When present, special care should be taken to avoid contact with contaminated groundwater, LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards (special care should be taken when sampling for PFAS. Please refer to Attachment C for details).

1.6 Cautions and Potential Problems

The following cautions or problems may be associated with well development:

- The observed presence of NAPL may warrant alternative goals and objectives for the well other than immediate development. The Project Manager should be contacted for direction on how to proceed.
- Low-yielding wells (e.g., at clay-bedrock interface, tight bedrock formations, etc.) may produce insufficient water to achieve optimal development including parameter stabilization.
- High-yielding wells (e.g., in coarse sand and gravel aquifers) may require the removal of large quantities of water to approach optimal development.
- Long well screens and/or larger diameter wells may require more time and effort to ensure adequate development of the entire interval depending on the development method employed.
- Development of wells should occur from the least-contaminated well to the most-contaminated well, if known.
- Overpumping is not as vigorous as surging and jetting and is probably the most desirable method for the development of new wells. The possibility of disturbing the filter pack is greatest with jetting well development methods, which are generally reserved for redevelopment of clogged extraction or injection wells. Surging or jetting may be preferred methods for supply, recovery, or injection wells (if constructed with metal screens) to achieve higher well efficiencies.
- The introduction of external water or air by jetting may alter the chemistry of the aquifer.
- Surging with compressed air may produce “air locking” in the water-bearing zone, preventing water from flowing into the well.
- Exercise caution with the use of surge blocks in PVC screen and pipe as the well could be damaged.
- Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casings are especially susceptible to becoming lodged (stuck) if used in well development applications.
- Prior to sampling a well, sufficient time should be allowed for equilibration with the formation after development. Refer to the governing regulatory agency for guidance regarding the required/recommended time interval between well development and sampling.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Well development will be completed on wells after the grout, annular seals, and protective casings are deemed sufficiently stable (i.e., 24 to 48 hours after installation) for the development method being utilized and/or after required regulatory agency timeframe requirements. Development may be performed immediately after well installation if grout is not used during well installation or if the sealant (i.e., bentonite seal) is above the water table, in accordance with the regulatory requirements. Various well development methods, including surging, pumping, hand bailing, and jetting, are summarized below, followed by step-by-step well development procedures.

2.1 Well Development Methods

Surging Method

Surge and Pump: To increase the effectiveness of well development, the well can be surged and then pumped. Surging may be accomplished in several ways, but essentially water is rapidly forced into and out of a well in a wash and backwash action. One method of surging is to simply turn the pump on for a few minutes and then turn it off for a few minutes. Surging can also be accomplished with a surge block, which is a piston-like device attached to the end of a drill rod or pipe. The block is plunged up and down along the screened interval, similar to a piston in a cylinder, to flush water in and out of the well. Periods of surging are typically followed by a period of water extraction to remove the sediment brought into the well. Surge blocks are best utilized for wells screened in lithologies of medium to high porosities and hydraulic conductivities. Exercise caution with the use of surge blocks in PVC screens which can be damaged by tight-fitting surge blocks.

A surge block method is used alternately with either a bailer or pump, so that materials that have been agitated and loosened by the surging action are removed. The cycle of surging-pumping/bailing is repeated until satisfactory development is achieved.

The surge block, usually attached and operated by a drill rig, is lowered to the top of the well screen and then operated in a surging action with a typical stroke of about three feet. The surging action is usually initiated at the top of the well screen and gradually worked downward through the screened interval so that sand or silt loosened by the surging action cannot cascade down on top of the surge block and prevent removal from the well. The surge block is removed at regular intervals and the fine material that has been loosened is removed by a bailer or pump.

Surging is initially gentle and the energy of the action is gradually increased during the development process. By controlling the speed, length and stroke of the surge block, the surging activity can range from very rigorous to very gentle.

Pumping Method

Pumping develops a well by creating a surging action as a result of variable flow rates. An electric submersible pump or compressed air-operated air displacement pump is installed into the well. The rate of flow is varied at levels adjacent to the well screen.

Overpumping: A simple method of well development is overpumping, where water is simply pumped from the well at a high rate.

Many pumps can also be used to surge a well, employing a similar method as with the surge block. While either off or running, the pump may be plunged up and down along the screened interval, in effect flushing water and sediment in and out of the well and adjacent filter pack.

Hand Bailing Method

Surge and Bail: Instead of a surge block, a bailer can be used in a similar manner since the diameter of the bailer is commonly slightly smaller than the diameter of the well. A water-filled bailer can be plunged up and down, followed by periods of bailing out sediment suspended in the water column. The impact of the bailer as it strikes the surface of the water produces an outward surge of water through the well construction and into the formation. This action tends to break sediment bridges that may have formed during well installation. Movement of water back into the well suspends fine sediments into the water column, which are removed with the bailer.

Bailers are good well development tools for wells screened in low-permeable formations. Deep wells or large purge volume wells should not be developed with bailers, as development with a bailer would be very labor intensive.

Jetting Method

Another method of development is high-velocity hydraulic jetting. Using a specialized jetting tool, jets of water are directed horizontally at the sides of the well from inside the well to loosen fine-grained material and drilling mud residue from the formation. The loosened material is flushed into the well and can be removed through concurrent pumping or by bailing. Caution should be used when using a jetting method of development as there is the possibility of disturbing the well filter pack. For product recovery, a jetting method of development can push product away from the well and can delay or completely prevent product from coming back into the well.

2.2 General Procedures for Well Development

1. The project plan will be consulted regarding any project-specific well development requirements.

2. Consult the well completion diagram and boring log to determine the well construction (well diameter, depth and length of screen), soil core vapor screening results, lithology of the screened interval, and depth to water.

3. If potable water was introduced into the water-bearing zone during well installation, the estimated amount of water lost to the formation during the drilling process should be removed during well development to ensure connection with formation water during the development process.

4. Select the appropriate method and equipment to implement development of the well. Ensure any non-dedicated equipment is clean and decontaminated prior to use and also in between wells. The development equipment should be the appropriate length to reach the entire length of the well screen. The method should be capable of evacuating the development water to the surface and into containers if required.

5. Measure the static DTW and total depth of the well using ECR SOP 004, and determine the amount of standing water in the well (well volume). Record the DTW and calculate the water column volume of the well.

   To calculate the volume of water in the well, the following equation (Equation 1) is used:

   Well Volume (V) = πr^2 h (cf)
   where:
   π = pi (3.14)
   r = radius of well in feet (ft)
   h = height of the water column in ft. [This may be determined by subtracting the DTW from the total depth of the well as measured from the same reference point.]
   cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

   The volume in gallons/linear foot (gal/ft) for common size wells are as follows:

Well Diameter (inches)	Volume (gal/ft)	Volume in Liters
2	0.1631	0.6174
3	0.3670	1.389
4	0.6524	2.470
6	1.4680	5.557

   If the volumes for the common size wells above are utilized, Equation 1 is modified as follows:

   Well volume = (h)(f)
   where:
   h = height of the water column (feet)
   f = the volume in gal/ft

6. Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.

7. Initiate water removal from the well and record the initial water quality measurements including pH, temperature, specific conductivity, DO, ORP and turbidity (as required by project specifications) in the field book or on the Well Development Form. Record any odors, water color/clarity, changes in air monitoring results or other observations in the field book or on the Well Development Form.

8. Optional step to estimate the permeability of the formation: Estimate flow rate of extracted water, in gallons per minute (gpm). The flow rate can be measured with a 5-gallon bucket and stop watch, or timed transfer to any vessel which can be measured. Measure DTW in the well during pumping to derive an estimate of water-level drawdown. Calculate the approximate specific capacity (gpm/ft of drawdown). Tracking the improvement of specific capacity can provide a direct measure of the effectiveness of well development and can determine when development is no longer providing improvement.

9. In general, well development should proceed until the following criteria are met (note: certain regulatory agencies may have more stringent well development requirements):

    a. Water can enter as readily as hydraulic conditions allow.

    b. A representative sample can be collected.

    - In general, representative conditions can be assumed when the water is visibly clear of sediments (e.g., turbidity <10 NTU).
    - In addition to clear water, a further criterion for completed well development is that the other water quality parameters mentioned above stabilize to within 10 percent between readings over one well volume. During well development, pH, specific conductivity, DO, ORP, temperature and turbidity can additionally be monitored to establish natural conditions and evaluate whether the well has been completely developed.

    c. The duration, along with any measured water quality parameters (e.g. pH, temperature, specific conductivity, DO, ORP and turbidity) should be recorded on the Well Development Form.

    In some instances, collection of a sample with a turbidity of 10 NTU or less is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met:

    - Several procedures have been tried,
    - Proper well construction has been verified,
    - Turbidity has stabilized within 10 percent over three successive well volumes, and
    - Specific conductivity and pH have stabilized over at least three successive well volumes.
      (It should be noted that pH, temperature, and specific conductivity may not stabilize if water quality has been degraded).

    d. The sediment thickness remaining in the well is less than 1 percent of the screen length or less than 0.1 foot for screens equal to or less than 10 feet.

    e. A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus, assuming 30 percent annular porosity) should be removed. If water was added as part of the well installation and development, attempts should be made to recover the volume of water added, plus the three well volumes.

10. Measure the total depth of the well, to determine the amount, if any, of sand/silt removed during development of the well.

11. Note the final water quality parameters in the field book or on the Well Development Form. The time between well development and sampling will depend on project objectives and regulatory requirements.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record well development measurements on field forms or in a field book. See Attachment A for an example of a Well Development Form.
- The following additional information should be recorded on the field form or in a field book:
  - Well/piezometer or monitoring point identification number
  - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
  - Date of well installation
  - Date(s) and time of well development
  - Static DTW before and after development
  - Quantity of water removed and initial and completion times
  - Quantity and source of water added to well to facilitate development, if applicable
  - Type and capacity of pump or bailer used
  - Description of well development techniques
  - Visual or sensory description (e.g., odors, product, etc.)
  - Time and date measurements were taken
  - Personnel performing the task
  - Weather conditions during task
  - Other pertinent observations
  - Measurement equipment used
  - Calibration procedures used
  - Decontamination procedures used

6.0 REFERENCES

U.S. EPA *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Monitor Well Development*, SOP 2044. October 23, 2001.

U.S. Geological Survey, Guidelines and Standard Procedures for Studies of Ground-Water Quality: *Selection and Installation of Wells, and Supporting Documentation*. Water-Resources Investigations Report 96-4233. 1997.

Ohio EPA, Division of Drinking and Ground Waters, *Chapter 8: Monitoring Well Development, Maintenance, and Redevelopment.* Technical Guidance Manual for Ground Water Investigations. February 2009 (Rev 2).

Sanders, Laura L. *A Manual of Field Hydrogeology*. New Jersey: Prentice-Hall, 1998. pp. 260-261.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	OCTOBER 2013	NOT APPLICABLE
1	AUGUST 2017	ADDED ATTACHMENT C TO ACCOMMODATE MODIFICATIONS REQUIRED WHEN DEVELOPING WELLS WHICH WILL BE SAMPLED FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

ATTACHMENT A

EXAMPLE WELL DEVELOPMENT FORM

TRC
Results you can rely on

Well Development Form

Project: **Project No.:** **Date/Time:** **Sheet __ of __**

TRC Personnel:

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Protective Casing Stick-up ______ ft. (from ground)

Riser Stick-up (from ground) ______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ ____

Well Depth ____ ft. ☐ top of riser ☐ top of casing ☐ ______ ☐ measured ☐ historical

Water Depth ____ ft.

Height of Water Column ____ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

PID SCREENING MEAS.

Background	
Well Mouth	

WELL MATERIAL ☐ PVC ☐ SS ☐ ____

Volume of Water in Well = _____ gallon(s)

[Vol. = r^2 h(0.163)] _____ Total gallons purged

FIELD WATER QUALITY MEASUREMENTS

Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									

Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									

EQUIPMENT USED:

NOTES/COMMENTS:

Signed:____________________ September 2013

ATTACHMENT B

SOP FACT SHEET

WELL DEVELOPMENT

PURPOSE AND OBJECTIVE

Well development is completed to (1) evacuate any water added during the drilling of wells, (2) establish a good hydraulic connection between the well and the surrounding water-bearing zone, (3) settle the sand pack and formation following the disruptive drilling and installation activities, (4) alleviate clogging, smearing or compaction of formation materials at the borehole wall due to the drilling process, and (5) remove fine particles (e.g., silt or clay) from the water column and sand pack in order to obtain groundwater samples that are representative of the water-bearing zone in which the well is installed and/or enhance groundwater extraction and injection rates. State and federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable.

WHAT TO BRING

- Field book or field forms
- Well keys, socket wrench, and device to remove standing water from flush-mount manholes.
- Water level meter and extra batteries
- Water quality meters, including turbidity meter
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing
- Bailer and cord
- Surge block
- Equipment decontamination supplies
- Indelible marking pens or markers
- Means of containerizing purge water

OFFICE

- Prepare/update the HASP; make sure the field team is familiar with the latest version.
- Review the work plan with the Project Manager and/or the field lead.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure, test equipment and make sure it is in proper working order.

ON-SITE

- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities, pedestrian traffic etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.

GENERAL DEVELOPMENT PROCEDURES

- Well development will be completed on wells after the grout, annular seals, and protective casings are deemed sufficiently stable (i.e., 24 to 48 hours after installation) for the development method being utilized and/or after required regulatory agency timeframe requirements.
- Measure the static water level and total depth of the well using RMD SOP 004, and determine the amount of standing water in the well (well volume). Calculate volume of water in one well volume.
- Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.
- Initiate water removal from the well and record the initial field water quality measurements including pH, temperature, conductivity, DO, ORP and turbidity (as required by project specifications) in the field book or on the Well Development Form. Record any odors, water color/clarity, changes in air monitoring results or other observations in the field book or on the Well Development Form.
- Well development procedures may include surging, overpumping, bailing, and jetting.
- Continue well development procedures until criteria have been met (e.g., turbidity <10 NTU, stabilization of water quality parameters, sediment thickness remaining in well is less than 1 percent of screen length) and a minimum of three times the standing water volume in the well has been removed.

WATER DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

ATTACHMENT C

SOP MODIFICATIONS FOR PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when developing wells where PFAS may be sampled. The following table highlights the required modifications to this SOP when sampling for PFAS.

<table>
<tr><th colspan="2">Well Development Protocols for PFAS</th></tr>
<tr><th>SOP Section Number</th><th>Modifications to SOP</th></tr>
<tr><td>1.3</td><td>• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during well development. This includes bailers, tubing, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape.
• High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing.
• Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used.
• Do not use Post-It Notes during sample handling or mobilization/demobilization.
• Do not use potable water for decontamination. Use deionized, distilled or organic-free water.
• Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.</td></tr>
<tr><td>1.5</td><td>Always consult the Site Specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to procedures:
• Tyvek® suits should not be worn during well development prior to conducting PFAS sampling events. Cotton coveralls may be worn.
• Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. PFAS-free rain gear (ponchos and umbrellas) that could be used during sampling can be purchased at IKEA stores.
• Stain resistant clothing should not be worn.
• Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only.
• Personnel involved with well development should wear powderless nitrile gloves at all times while handling tubing or equipment. Avoid handling unnecessary items with powderless nitrile gloves. A new pair of gloves must be donned prior to developing each well.
• Wash hands with Alconox® or Liquinox® and deionized water after leaving vehicle before setting up at a well development location.</td></tr>
</table>

Well Development Protocols for PFAS	
SOP Section Number	**Modifications to SOP**
1.6	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work. • Avoid using sunscreens or insect repellants that are not natural or chemical free.

Notes:
[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

Title: **Well and Borehole Abandonment/Decommissioning**	Procedure Number: **ECR 021**
	Revision Number: **0**
	Effective Date: **January 2017**

Authorization Signatures

Jamie Stapleton		Elizabeth Denly	
Technical Reviewer Jamie Stapleton	Date 1/19/17	ECR Practice Quality Coordinator Elizabeth Denly	Date 1/18/17

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Page No.

ATTACHMENTS

Attachment A Example Abandonment/Decommissioning Records

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the management of groundwater monitoring, recovery, injection, or soil vapor well, and soil, rock, or grab groundwater boring abandonment. This SOP details equipment, materials, and procedures for abandonment (also referred to as decommissioning). This SOP assumes wells have been installed and developed in accordance with TRC SOPs 006 and 007, respectively. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., method, material mix ratios, sealing report/form submittal, etc.) that may be applicable, depending on the program. Most, if not all, states require abandonment to be conducted by a licensed well drilling contractor.

The objective of well abandonment is to properly remove a groundwater monitoring or recovery well from service and prevent the well from being a preferential pathway for oil or hazardous materials to reach the aquifer from the surface. Sealing a well or boring should be done in a manner to prevent the mixing of water from separate water bearing zones, and in accordance with local, state, and federal regulations as applicable.

1.2 Summary of Method

To take a well out of service the well is either removed from the ground via physical means or the well is filled with aggregate, neat cement grout, concrete grout, and/or bentonite chips. Soil borings need to be backfilled with native material or materials similar to those used during well decommissioning.

1.3 Equipment

The following equipment should be used when abandoning a well or boring. Site-specific conditions may warrant the use of additional equipment and/or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE)
- Water level measuring device, capable of measuring to 0.01 foot accuracy
- Well keys
- Map of well locations
- Well construction data
- Photoionization detector (PID) for work area/well head monitoring (as determined appropriate based on prior site investigation findings or if unknown conditions)
- Oil/water interface probe (if non-aqueous phase liquid [NAPL] present)
- Field Logbook
- Indelible marking pens
- Project-specific work plan

1.4 Definitions

Aggregate	Coarse grained granular materials like natural sand, gravel, and cobbles.
Annulus	The space between the casing in a well and the wall of the borehole.
Borehole	A hole drilled into the soil or bedrock using a drilling rig, or similar equipment.
Bridging	When materials for well construction or abandonment are poured into the borehole or well but get caught up inside the well which prevents materials from being installed in the proper elevations.
Dense Non-Aqueous Phase Liquid (DNAPL)	Separate phase product that is denser than water and therefore sinks to the bottom of the well or aquifer.
Depth To Water (DTW)	The distance to groundwater from an established measuring point.
Flame Ionization Detector	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured by the detector.
Flush Mount	The type of well construction where the riser terminates at or below grade. Flush mount wells are typically completed with a "curb box" which is an "at-grade" enclosure designed to protect the well riser.
Grout	An approved material for use in sealing the annular space of a well during construction or for sealing a well or borehole during decommissioning.
Grout Additives	Some bentonite (2 to 8 percent is industry standard) can be added to neat cement or concrete grout to decrease the amount of grout shrinkage during curing.
Grout Pump	A pump designed to handle high viscosity fluids (e.g. grout) and transfer the mixture into a well or borehole under pressure.
Light Non-Aqueous Phase Liquid (LNAPL)	Separate phase product that is less dense than water and therefore floats on the surface of the water table.
Over-drilling	The process of drilling out a well casing and any material placed in the annular space.
Photoionization Detector (PID)	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.

Protective Casing	The pipe installed around the well riser that sticks up from the ground in order to protect the well. Protective casings are usually constructed of steel with a closeable lid with a locking cover to maintain well integrity.
Separate Phase Product	A liquid that does not easily dissolve in water due to differences in specific gravity. Separate phase product can be denser (DNAPL) or less dense (LNAPL) than water and therefore can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressures.
Tremie Pipe	A pipe utilized for the purpose of conveying grout to the base of the well or borehole. The tremie pipe is usually attached to the grout pump with a hose.
Well Cover	The cap or lid constructed at the end of the protective casing or flush-mounted curb box to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes are opened and closed using a threaded bolt.
Well Filter Pack	The filter pack is placed into the borehole annulus around the well screen during well construction. The filter pack typically is constructed of clean and graded sand and is used to replace formation materials and separate the well from the natural formation.
Wellhead	Sometimes referred to as a well mouth, this is the opening at the top of the well casing where the well is accessible once the well cap or plug is removed.
Well Plug/Expansion Plug	A pipe plug fashioned into a cap placed into the top of the well riser. Well plugs are usually designed with an expandable gasket which is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.
Well Riser	The section of well extending from the well screen to or above the ground.
Well Seal	The use of grout, concrete, and/or bentonite materials to create a well seal in the well or borehole created during drilling. As opposed to use of granular materials (e.g. sand) which can allow the transmission of water through the material.

Well Screen	The slotted or perforated section of the well that allows groundwater to enter the well. The screen supports the aquifer material and prevents the borehole from collapsing into the well. The well screen is commonly surrounded by a sand pack.

1.5 Health & Safety Warnings

TRC employees will be on site when implementing this SOP and therefore, shall follow the site-specific Health & Safety Plan (HASP). TRC personnel will use the appropriate level of personal protective equipment (PPE), as defined in the HASP. Implementing this work may involve physical hazards such as movement of heavy tools or bags of materials. TRC personnel should not enter the area where the mixing of material takes place unless needed.

If VOCs are a suspect or known site contaminant of concern or the subsurface contaminant conditions are unknown, the well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

The final condition of the abandoned well area shall not be a safety hazard to the public.

1.6 Cautions & Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization in the field.

(a) Verify with the Project Manager that the proposed work plan is compliant with state specific requirements.

(b) Verify with the Project Manager that the targeted well does not contain dedicated equipment (e.g. pumps, bailers, tubing, absorbent materials) and if present, be prepared to remove.

(c) If wells are suspected to have been installed improperly, over-drilling should be considered the primary method of well abandonment because the materials surrounding the well may be a preferential pathway for the vertical movement of water.

(d) Wells which are over-drilled will generate cuttings which may have broken PVC fragments and/or contain contaminated soil; the cuttings should be carefully managed as opposed to simply landscaped. If a well has historically contained NAPL, some NAPL may be attached to the PVC and/or sand pack even if no NAPL is measured on the water table in the well.

(e) Wells screened across multiple aquifers or hydrostratigraphic units should be abandoned using a grout sealant, as opposed to aggregate.

(f) If not included in the work plan, discuss with the Project Manager the intended final condition of the area where the road box or standpipe and collar currently exists. For example, if a road box and concrete collar protect a well in a paved area, the void generated by the removal of the road box and concrete should be filled with either concrete, cold asphalt, hot asphalt, etc, as appropriate.

(g) For wells and borings which are abandoned via bentonite chips and/or aggregate materials the driller and the TRC representative should monitor the feed rate of these materials to the well or borehole in order to guard against bridging inside the well.

(h) In instances where extraordinary conditions are present, such as a high concentration of mobile contaminant in the overburden, a shallow depth to water, and/or poor construction documentation or shoddy well construction, temporary casing installation may be necessary outside of the well casing prior to the over drilling in order to prevent cross contamination.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. In addition, all personnel utilizing this SOP must have completed the following:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Workers (HAZWOPER)
- 8-hour annual refresher training

In addition to the 40-hour initial OSHA training (and annual 8-hour refresher training), all TRC field staff will complete 24 hours of supervised field experience that contribute toward the 24-hour field supervised requirement in compliance with OSHA regulation: 29 CFR 1910.120(e)(4).

2.0 MATERIALS

The following is a list of commonly used materials for well and borehole abandonment which are also included in Section 1.4 above.

Aggregate	Angular fine to coarse gravel can be utilized in limited applications.
Bentonite Chips/Pellets	Chipped or pelletized bentonite can be poured into a well and will swell in the presence of water. Bentonite chips or pellets present above the water table need to be hydrated. Pellets or chips should only be used when they are being dropped down an open borehole and hydrated in place.
Bentonite Grout	A mixture of one 94-pound bag of Portland cement and no more than 6 gallons of water, and 4 pounds bentonite.
Bentonite Powder	Powdered or granular bentonite can be used alone with potable water or mixed with cement and potable water to form a grout slurry. Powdered bentonite must be used for grout mixes to ensure proper mixing.
Concrete Grout	A mixture of one 94-pound bag of Portland cement and an equal volume of sand and no more than 6 gallons of potable water.

Neat Cement Grout	A mixture of one 94-pound bag of Type I Portland cement and no more than 6 gallons of potable water.
Powdered Bentonite	A mixture of one 94-pound bag of Portland cement and no more than 6 gallons of potable water, and 4 pounds bentonite.
Special Mixture Bentonite Grout	A mixture of one 94-pound bag of Portland cement and no more than 6-8 gallons of potable water (depending on desired thickness), 1 pound calcium chloride, and 4 pounds powdered bentonite. This grout mix sets faster than typical bentonite grout due to the calcium chloride.

3.0 PROCEDURES

Procedures for abandonment of monitoring wells and boreholes are described below. In order to properly decommission a well, it is important to know the original construction and local regulatory requirements. There are several methods for decommissioning a well. Local regulatory requirements may not allow the use of some of the procedures listed below. In addition to local regulatory requirements, the method used largely depends on casing diameter and materials, annular material, and well depth. Special considerations may need to be made for nested wells and single and double cased wells which may require different approaches than those described below.

3.1 Well Inspection

(a) Prior to proceeding with abandonment, record the depth to water and depth to bottom of the well using either an oil/water interface probe or an electronic water level meter and a weighted tape measure, depending on whether there is record of NAPL at the site. (refer to TRC SOP 004, *Water Level and Product Measurement*). These measurements allow the driller to understand the actual well depth (as opposed to historical depth from the well logs) as well as allow the TRC representative to verify the well is the one intended to be abandoned. Any dedicated pumps, tubing, tethers, etc. must be removed prior to well abandonment.

(b) Prior to field activities, review historical well logs, if available, to verify well depth. It is also important to understand the well construction, materials, diameters of boreholes and annular material used during construction of the well, type of lithology surrounding the well, etc. in order to help identify the appropriate methods to consider for abandonment and to ensure that the drilling contractor has sufficient equipment and sealing materials onsite.

(c) Inspect the well for any obstructions or any other conditions that may interfere with the abandonment of the well.

3.2 Abandonment of Wells and Boreholes

The most effective way to reduce the potential for the well or annular materials to serve as a preferential vertical pathway is to decommission wells by removing all existing well construction materials (screen, casing, filter pack, etc.). However, the complete removal of the well and annular material is not always feasible or necessary based on multiple factors such as site conditions, hazardous materials present, well construction, etc. There are two general procedures

– 1) the physical removal of the well and 2) leaving the well casing in place, followed by filling the borehole/well casing with a grout mix or bentonite pellets/chips. The method of sealing the well casing or borehole is often chosen based on depth. For example, it may be appropriate to fill shallow well or casing using bentonite pellets/chips, however, it is not recommended, and is often not allowed, for deeper wells.

3.2.1 Well Casing Removal

3.2.1.1 via Pulling

Shallow wells (generally less than 20 deep) may be able to be removed by the driller by 'pulling' the well casing/screen out of the borehole. For deeper wells or shallow wells with strong annular seal, the casing may be removed with the assistance of jacks and lifted using a drill rig, back hoe, crane, etc. If the well casing is pulled out, then the remaining void shall be filled in with neat cement grout, or for shallow wells or borings, hydrated bentonite chips. Ideally, the grout should be injected during the removal of the well and while this is not always possible it should always be attempted. Larger diameter wells (i.e., greater than 2 inches diameter) may not be able to be 'pulled' from the ground. If conditions warrant protection of a confined aquifer during abandonment, then a temporary steel casing could be driven around the outside of the well to facilitate removal of the well and proper sealing of the borehole while minimizing mixing of the aquifer.

If the well casing cannot be simply pulled using manual labor by the drilling crew, a hole may be drilled in the riser pipe to create a connection point, a connecting bolt inserted, and the well pulled using jacks or cable on the drilling rig. Prior to pulling the casing, it is recommended to perforate the bottom of the well so that the casing is partially pulled and it breaks such that it cannot be fully extracted (which happens often with PVC wells), the void space under the remaining casing can still be plugged.

If the work scope requires complete removal of the entire well casing and the casing cannot be pulled, over-drilling is necessary as described below.

3.2.1.2 via Over-drilling

Over-drilling is an effective means to insure that the casing can be pulled or eliminated, especially in cases where the annular material needs to be removed to get a good seal (often when multiple hydrostratigraphic units are present).

(a) Remove road box and concrete collar and retain lid for future use if in good condition.

(b) Utilize air or mud rotary, hollow-stem auger, or other drill rig depending upon actual site conditions and well construction (e.g. air or mud rotary when cement grout is present). Mud rotary is the most effective drilling method to over-drill a boring and remove the casing and well construction materials. Over-drilling with hollow-stem augers (with outward facing teeth) can allow for pulling the casing out of the original borehole. In either case, advance the drilling tools to remove all well material within the original borehole. Observe progress to ensure the drilling tools do not wander off the well. Utilize a pilot bit if necessary. The over-drilling should advance a short distance into the native material.

(c) Abandon the borehole using sealants as described below in Section 3.2.4.

(d) Finish to grade as discussed in Section 3.3.

3.2.2 Abandonment of Boreholes and Wells Using Bentonite Chips

If the well is not able to be pulled, the well can be abandoned by installation of bentonite chips/pellets and hydration of chips which are above the water table or cement grout. Soil borings 20 feet or shallower if not abandoned by backfilling with drill cuttings can typically be abandoned using bentonite pellets or chips. The bentonite should be hydrated at five foot intervals when backfilling above the water table. During backfilling with bentonite chips/pellets, the amount of bentonite used and the depth to bentonite inside the well must be monitored to watch for bridging inside the well. In unpaved areas the bentonite should be installed to a depth of one foot below grade and the area capped with compacted soil. In paved areas, the surface completion should follow procedures in Section 1.6 (f).

3.2.3 Abandonment of Shallow Borings with Unconsolidated Materials

Natural aggregate or native soil can be used to abandon shallow soil borings in the event that the removed soil is not suitable for reuse. The aggregate material can be compacted with a tamper (manual or pneumatic) and which should be done in lifts. For work in California the natural aggregate must be well-proportioned mixes of silts, sands, and clays, and native soils that have a coefficient of permeability less than 10 feet per year. Typically, a tamper is only able to reach five feet or less into the borehole. A pneumatic tamper is recommended if a high degree of compaction effectiveness is required. The abandoned boring should be completed with concrete or asphalt as applicable to match existing surface conditions and is not intended for use in unpaved areas unless the aggregate used has an equal or lower transmissivity then the surrounding materials.

3.2.4 Abandonment Using Sealant and Tremie Pipe

One method commonly used for sealing both shallow and deep boreholes and wells is by injecting plugging material into the well or bore hole through a Tremie pipe. This method is required for deeper wells by local regulations. The grout is injected slowly through the tube starting from the bottom of the well and slowly raised through the boring or well casing. The following are general steps for this common procedure:

(a) Remove lid from road box or protective casing (as applicable) and retain for future use if in good condition.

(b) Mix the hydraulic sealant (typically bentonite and grout mixture) to specification.

(c) If destroying gravel-packed wells or if the well seal is compromised, the casing should be perforated or punctured in order for the sealant to be forced into the gravel pack.

(d) Install a tremie pipe down to the base of the well or borehole.

(e) Using a grout pump, pump the mixture into the base of the well via the tremie pipe. Use special mixture bentonite grout for abandoning the screened portion of wells which are set in highly fractured bedrock (e.g., limestone) or high permeability sand aquifers.

(f) Pump mixture until the level of the mixture is close to the top of the casing. While pumping, gradually raise the tremie pipe such that the bottom remains below the level of the sealant mixture.

(g) Remove any outer protective surface casing after the well has been properly filled with grout. This will ensure that the well is properly sealed regardless of any breakage that may occur when removing the stick-up.

(h) Finish surface to grade as described in Section 3.3.

3.3 Final Surface Condition

Consideration should be included in the work plan as to how the surface should remain upon completion of the work as mentioned in Section 1.6(f).

(a) For wells being decommissioning in place, remove any protective surface casing (stick-up cover or traffic box, if necessary) after the well casing has been properly sealed using one of the procedures above in Section 3.2.

(b) The well or borehole should be filled to within two feet of the top of the casing or ground surface and either capped with cement or backfilled with compacted soil prior to finishing at the surface to match existing surface conditions. If well casing is abandoned in place then the uppermost few feet should be removed. Various states often specify a minimum depth below grade that the casing must be removed. Note that New York and California may require the upper five feet to be removed and capped and then backfilled with clean soil.

(c) Modify final surface conditions pursuant to the work plan. Note that EPA recommends adding a piece of metal to the top of an abandoned well grout so the location can be identified later using a metal detector.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

(a) Verify that the proposed work plan is compliant with state specific requirements which may include completion and/or submittal of a Well Abandonment Record.

(b) TRC personnel should observe the preparation of mixtures used to abandon the well in order to ensure accuracy and quality. A field check can be conducted by performing a comparison of the borehole or well volume relative to the volume of bentonite pellets or grout utilized.

(c) Water utilized for well abandonment shall be of potable drinking water quality. Water with high levels of chloride or sulfate (above drinking water standards) may interfere with the quality of cement-based sealing mixtures.

(d) The driller should be monitoring the accumulation of bentonite pellets/chips in a borehole or well. If the accumulation rate does not match the application rate, bridging may be occurring and the procedure must be stopped until the problem is remedied.

(e) If the well has significant accumulated silt (i.e., greater than one foot), the well should be re-developed prior to in-place abandonment. If redevelopment is infeasible and the well is shallow and constructed with a PVC riser/screen, the well may be split and the void filled with sealant. Splitting may be conducted several ways including using drill rods on a direct push technology rig.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The following should be recorded in the field book or on the field form:

- Drilling contractor name, equipment and method used;
- Personnel performing the task;
- Well number, depth, diameter, material, and location (coordinates, if known);
- Well permit number (if applicable);
- Depth to water prior to abandonment;
- Document if casing remains in place or completely removed;
- Types and volumes of sealant material used (e.g., neat cement, bentonite); and
- Amount of potable water used and source of water.

Note that many states require submittal of a well sealing report or documentation that the well has been decommissioned. In some cases, these forms must be submitted by the licensed drilling contractor. Understand the requirements where the work is taking place and ensure that the well abandonment is documented accordingly.

6.0 REFERENCES

Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities. ASTM D5299 - 99(2012)e1. Book of Standards Volume: 04.08. Reapproved 2012.

Guidelines for Well and Boring Abandonment. Maine Department of Environmental Protection. Bureau of Remediation and Waste Management. January 7, 2009.

Groundwater Quality Rules. Rhode Island Department of Environmental Management. Office of Water Resources. June 2010.

Environmental Protection Rules – Chapter 21: Water Supply Rule. Vermont Agency of Natural Resources. Vermont Department of Environmental Conservation. December 1, 2010.

Private Well Guidelines. Massachusetts Department of Environmental Protection. Drinking Water Program. October 2008.

New Hampshire Code of Administrative Rules. Administrative Rules We 603 Well Maintenance and We 604 Abandonment of Wells (Water Well Board Administrative Rules, Chapters We 100-1000).

Standard References for Monitoring Wells – Small Diameter Driven Well Supplement. Massachusetts Department of Environmental Protection. Bureau of Waste Site Clean-up. January 1999.

Groundwater Monitoring Well Decommissioning Procedures. New York State Department of Environmental Conservation. Division of Environmental Remediation. August 2009.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2017	NOT APPLICABLE

Attachment A:

Example Abandonment/Decommissioning Records

PAGE ______ OF ______

MONITORING WELL DECOMMISSIONING LOG

PROJECT NAME:		**MONITORING WELL ID:**	
PROJECT NUMBER:	DATE:	LOCATION:	LOCATION COORDINATES:
OBSERVED BY:			N:
DRILLING CONTRACTOR:			E:
CREW CHIEF:		TOP OF CASING ELEV.: ________	SURFACE ELEV.: ______

PROTECTIVE COVER TYPE:	☐ STICK-UP ☐ FLUSH MOUNT ☐ TRAF. BOX ☐ OTHER ____________
PROTECTIVE COVER DIAMETER:	☐ 4" ☐ 8" ☐ 9" ☐ 10" ☐ 12" ☐ OTHER ____________
WELL MATERIAL:	☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER ____________
WELL CASING DIAMETER:	☐ 1" ☐ 2" ☐ 4" ☐ 6" ☐ 8" ☐ OTHER ____________
WELL SCREEN MATERIAL:	☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER ____________
WELL SCREEN LENGTH:	☐ 5-FT ☐ 10-FT ☐ UNKNOWN ☐ OTHER ____________ **DTW:** ____________ T/ PVC
WELL SCREEN SLOT SIZE:	☐ 0.01" ☐ 0.02" ☐ UNKNOWN ☐ OTHER ____________ **DTB:** ____________ T/ PVC

DECOMMISSIONING PROCEDURE:

NOTES: **(include equipment and methods used and whether any casing remains in place or is completely removed)**

GROUTING PROCEDURE:	NOTES: **(include source and amount of potable water used)**
GROUT TYPE:	
GROUT MIX:	
GROUT INTERVAL: ______ FT-BGS TO ______ FT-BGS	
BENTONITE SEAL:	
SEAL INTERVAL: ______ FT-BGS TO ______ FT-BGS	

ADDITIONAL COMMENTS:

SIGNED ________________ DATE ________ CHECKED ________________ DATE ________

REVISED 06/2011

WELL DECOMMISSIONING RECORD

Site Name:	Well I.D.:
Site Location:	Driller:
Drilling Company:	Inspector:
Inspector Company:	Date:

DECOMMISSIONING DATA (Fill in all that apply)

OVERDRILLING

Interval Drilled	
Drilling Method(s)/Equipment	
Borehole Dia. (in.)	
Temporary Casing Installed? (y/n)	
Depth temporary casing installed	
Casing type/dia. (in.)	
Method of installing	

CASING PULLING

Method employed/Equipment used	
Casing retrieved (feet)	
Casing type/dia. (in.)	

CASING PERFORATING

Equipment used	
Number of perforations/foot	
Size of perforations	
Interval perforated	

GROUTING

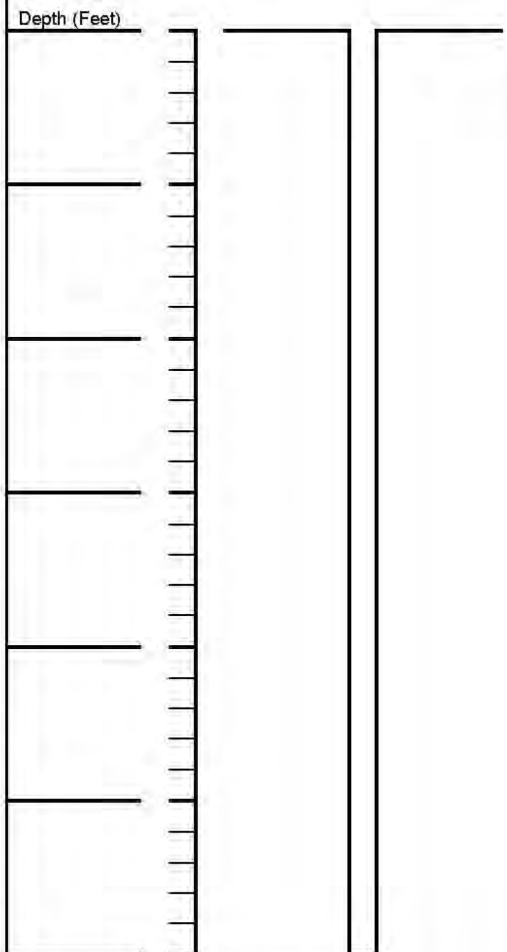
Interval grouted (FBLS)	
# of batches prepared	

For each batch record:

Quantity of water used (gal.) & source	
Quantity of Cement used (lbs.)	
Cement type	
Quantity of bentonite used (lbs.)	
Quantity of calcium chloride used (lbs.)	
Volume of grout prepared (gal.)	
Volume of grout used (gal.)	

LOCATION COORDINATES:
N:________________ E:________________

WELL SCHEMATIC



*Sketch in all relevant decommissioning data, including: depth to water, depth to bottom, well diameter/material, interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS: ________________________________

Inspector Signature ____________________

Potentiometric Surface Measurements and Soil/Water Sampling Procedures

Title: **Surface Water and Sediment Sampling**	Procedure Number: **RMD 008**
	Revision Number: **0**
	Effective Date: **April 2014**

Authorization Signatures

Technical Reviewer 4/7/14 Date Kenneth Cormier	Remediation Practice Quality Coordinator 4/7/14 Date Elizabeth Denly

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Page No.

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the logistics, collection techniques, and documentation requirements for collecting representative surface water and sediment samples. This SOP is applicable to the sampling of surface water and sediment in both flowing and standing water in marine, estuarine or freshwater environments. These are standard (i.e., typically applicable) operating procedures that may be changed, as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In addition, other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field book.

1.2 Summary of Method

The objective of surface water and sediment sampling is to obtain a representative sample of these media for analysis of physical and/or chemical parameters, as necessary, at a given site. This objective requires that the sample be both free of unsuitable material and be of sufficient quantity and quality for analysis by the selected analytical method. Sediment and surface water samples are collected either directly using a hand-held device or indirectly using a remotely activated device. In some instances, direct push drilling equipment may be appropriate for sediment sampling and the procedures in TRC's RMD SOP 003, Soil Sampling, would be applicable.

1.3 Equipment

The following equipment may be utilized when collecting surface water and sediment samples. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

1.3.1 General Equipment

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP) including additional safety gear for working in or near water (e.g., harness, life jacket, tether, flotation device, etc.)
- Photoionization detector (PID) or flame ionization detector (FID)
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags
- Tape measure, folding ruler
- Boat (if needed) with anchor
- Indelible marking pens or markers
- Field book and/or Sample Log Form
- Sample container labels
- Chain-of-custody (COC) forms (TRC or laboratory, as appropriate)
- Organic absorbent (e.g., Slickwick, ground corn cob, sawdust)
- Buoys
- Camera
- Compass
- 5-gallon bucket
- Wire/rope
- Calibrated staff
- Maps/site plan

- Equipment decontamination supplies
- Sample coolers
- Bubble wrap
- Ice (for sample storage/preservation)
- Zip-loc® plastic bags (for ice and COCs)
- Thermometer
- Barometer
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Survey equipment and/or global positioning system (GPS) and/or other means of establishing sample locations
- Hip/chest waders
- Rubber boots

1.3.2 Surface Water Sampling Equipment

- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, oxidation-reduction potential, and dissolved oxygen [DO]). Note: Salinity probe may be needed depending on project requirements.
- Turbidity meter
- Sample collection tool options**
    - Dip sampler
    - Kemmerer bottle
    - Peristaltic pump
    - Van Doren sampler

    **The deployable samplers will typically be manufactured of stainless steel, Teflon®, or glass.

- Teflon®, Teflon®-lined polyethylene, or high density polyethylene (HDPE) tubing, dependent upon project objectives
- Filtration equipment, if required (peristaltic pump and 0.45 micron [μm] filters, or as otherwise required for the project)
- Graduated cylinder or five-gallon bucket
- Stop watch
- <u>Sample containers</u> (may be supplied by the laboratory, depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project.

1.3.3 Sediment Sampling Equipment

- Sample collection tool options
    - Spade or shovel (stainless steel or plastic)
    - Scoop (stainless steel or plastic)
    - Trowel (stainless steel or plastic)
    - Hand auger
    - Bucket auger
    - Tube auger head (core sampler with removable liner)
    - Sand auger head
    - Mud auger head
    - Acetate liners

  - Extension rods
  - Sediment coring device (i.e., vibracore, gravity core, etc.)
  - Ponar or equivalent grab sampler
  - Eckman dredge
  - Nylon rope or stainless-steel cable
  - Two adjustable wrenches and a slip wrench
  - Nylon tube brush
  - Wire brush for thread cleaning
- Stainless-steel mixing bowl or disposable aluminum tray
- Stainless-steel spatulas or spoons
- Small scale to measure sample mass
- Dedicated Teflon® spoons (if required)
- Sample containers (may be supplied by the laboratory, depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project.

  For non-volatile organic compound (VOC) parameters, glass containers with Teflon®-lined caps are typically utilized. Typical containers used for VOC parameters are provided in Attachment A. However, one of the following samplers is typically used based on sample consistency (e.g., fluidity, coarse fraction).
  - En-Core® samplers.
  - Disposable plastic syringes or Terra Core™ samplers.

1.4 Definitions

En-Core® sampler	A disposable volumetric sampling device with an airtight sealing cap.
High-level VOC analysis	VOC sediment analysis that yields high reporting limits (approximately 50-200 μg/kg depending on the laboratory). Samples are typically preserved in methanol and cooled to 4°C. High-level VOC analyses are used for samples that are expected to contain elevated concentrations of VOCs (>200 μg/kg).
Low-level VOC analysis	VOC sediment analysis that yields low reporting limits (approximately 5 μg/kg depending on the laboratory). Samples are typically preserved in water, cooled to 4°C, and frozen within 48 hours of collection. Low-level VOC analyses are used for samples that are expected to contain lower concentrations of VOCs (<200 μg/kg).
Sediment	Mineral and organic materials situated beneath an aqueous layer.
Terra Core™ sampler	A disposable volumetric sampling device used to transfer soil samples to the appropriate sample containers.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE, as defined in the HASP.

Sediment or surface water samples containing chemical contaminants may be handled during implementation of this SOP. Additionally, sample preservatives including caustics and/or acids may be considered hazardous materials and TRC employees will appropriately handle and store them at all times. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Hazardous substances may be incompatible with clothing or equipment; some substances can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through inhalation or skin contact or if exposed to heat/flame and they combust. Material safety data sheets for chemicals handled by TRC should be maintained in the field.

A hazard analysis specifically addressing the project-specific water hazards must be included in the HASP.

1.6 Cautions and Potential Problems

1.6.1 Surface Water Sampling

- When collecting surface water using the direct-fill method:
  - the sample container should generally be held below the surface to avoid collection of floating debris.
  - if pre-preserved sample bottles are used, care must be taken to avoid loss of preservative.
- Make sure monitoring instruments (e.g., multi-parameter meter) are maintained and calibrated to ensure accurate readings.
- Clear tape should not be used to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.
- Surface water sampling should proceed from the downstream locations to the upstream locations.
- Be sure to obtain all necessary permits prior to sampling in water bodies, if applicable.
- Where metals constituents are to be analyzed, filtration in the field may be required. Extra bottles may be necessary depending on sampling technique (e.g., dip sample collection; field filtering to a second bottle onshore). Samples should also be collected for hardness analysis to allow for direct comparison of data to ambient water quality criteria.

1.6.2 Sediment Sampling

- Clear tape should not be used to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment or the ability to obtain accurate post-sampling weights.

- Decanting the overlying water should be done carefully to minimize any loss of fine-grained sediment and organic matter.
- Homogenization should be performed quickly and efficiently in order to avoid altering the particle-size distribution of a sample and to avoid oxidation of the sediments. Homogenization should not be performed for VOC analysis.
- If free product is encountered in sediment, consult with the Project Manager prior to shipping the sample to the laboratory.
- Sediment sampling should proceed from the downstream locations to the upstream locations.
- Samples collected for low-level VOC analysis must be shipped to the laboratory as soon as possible due to the fact that these samples must be frozen by the laboratory within 48 hours of collection.
- Sediment sampling often presents challenges due to working near/within water stream flow conditions, working in a boat, etc. along with often difficult substrate (cobbly river bottom, mucky conditions, etc.). Sampling surface sediment beneath a shallow aqueous layer with spades, shovels, trowels, and scoops may not be an accurate or feasible method with deep and rapidly flowing water. It is recommended to have multiple methods of sampling equipment on-hand to improve chances of obtaining appropriate/representative samples of sufficient volume.
- Headspace readings of sediment samples using a PID may be unreliable due to the high moisture content of the samples.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Always refer to the site-specific work plan and/or scope of work for any site-specific sampling procedures.

2.1 Order of Sample Collection

If both sediment and water samples are to be collected concurrently, each water sample should be taken prior to the corresponding sediment sample in order to avoid introducing sediment into the water column from sediment collection activities. Depth to the bottom must be accurately known in order not to disturb sediment during surface water collection. If water depth is unknown or not observed, use a calibrated rod, tape, or line to measure the depth to the bottom or refer to a known bathymetric survey if possible.

In flowing streams or runoff channels, water and sediment samples should be collected first from the furthest point downstream (with each water sample collected before the sediment sample). The remaining samples will be taken while proceeding upstream. In tidal situations, prior to mobilization, determine the tidal sequence and monitor the direction of tidal flow in order to determine the proper sampling sequence.

2.2 Surface Water Sampling Procedures

Samples should be taken without disturbing the sediments, which would include the results of actions such as entering the surface water body. This may be accomplished by the use of a remote sampler (e.g., a sample bottle held on a long pole with a gimballed yoke).

Prior to collecting surface water, calibrate the water quality parameter instrument and turbidity meter in accordance with the site-specific work plan.

2.2.1 Sampling Surface Water at a Discrete Depth

- The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position, thus allowing free passage of water through the cylinder. This sampler is recommended when the sampling location is accessed from a boat or structure, such as a bridge, and where samples at specific depths are required.
- The Van Dorn sampler is plastic and is lowered in a horizontal position. This sampler is recommended when collecting surface water from a very specific sampling depth or from a shallow water body.

In each case, a messenger is sent down a rope when the sampler is at the designated depth, causing the stoppers to close the cylinder. The sampler is then raised to the surface.

1. Set the decontaminated Kemmerer bottle or Van Dorn sampler so that the upper and lower stoppers are pulled away from the body.

2. Lower the sampler to the predetermined depth. Avoid disturbance of the bottom.

3. When the sampler is at the required depth, send the weighted messenger down the suspension line to close the sampler.

4. Retrieve the sampler and discharge the first 20 mL from the drain.

5. Proceed to Section 2.2.5 for filling of sample containers and/or if filtering is required.

6. Repeat steps 1-4 if additional sample volume is needed to fulfill analytical requirements.

2.2.2 Sampling Surface Water with a Dip Sampler

A dip sampler is useful for situations where a sample is to be recovered from an outfall pipe or along a bank where direct access is limited. The long handle on such a device allows access from a discrete location.

1. Assemble the device in accordance with the manufacturer's instructions.

2. Extend the device to the sample location and collect the sample.

3. Retrieve the sampler and transfer the sample to the appropriate container.

4. Proceed to Section 2.2.5 for filling of sample containers and/or if filtering is required.

2.2.3 Sampling Surface Water Using the Direct Fill Method

This sampling method is recommended for streams, rivers, lakes and other surface waters.

1. For shallow streams, collect the sample <u>under</u> the water surface while pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. A clean intermediate collection container may be necessary to fill bottles to the top since this technique is limited by the depth of the waterbody. If pre-preserved containers are used for direct filling of the bottle, care must be taken to avoid the loss of preservative into the surface water body.

2. For lakes, collect the sample under the water surface while avoiding surface debris.

3. Proceed to Section 2.2.5 for filling of sample containers and/or if filtering is required.

2.2.4 Sampling Surface Water with a Peristaltic Pump

This sampling method is recommended when collecting samples from a boat.

1. Connect Teflon®, Teflon®–lined polyethylene, or HDPE tubing (dependent upon project objectives) to the peristaltic pump.
2. Lower tubing to the predetermined depth. Avoid disturbance of the bottom.
3. When the tubing is at the required depth, start the pump. Measure the flow rate of the pump with a graduated cylinder and stop watch. Record the volume of water collected for a period of one minute and calculate the flow rate as follows.

$$Flowrate\ (L / min) = \frac{volume\ collected\ \ (mL)}{1\, minute}\ x\ \frac{1\ L}{1000\ mL}$$

4. When the flow rate is set, start filling the containers. Refer to Section 2.2.5 for filling of sample containers and/or if filtering is required.

5. If collecting samples at the same location at different depths, tubing must be purged for a minimum of one tubing volume, to ensure water from previous depths is no longer in the tubing.

6. When collecting samples for chemical contaminants, the tubing must be changed between sample locations. If only sampling for water quality measurements (e.g., pH, conductivity,

DO, total suspended solids [TSS], etc.), tubing does not have to be changed; however, step 5 must be followed between locations.

2.2.5 Sample Collection for Laboratory Analyses

1. Surface water samples for specific analytical fractions should be collected in the following order:

    a. VOCs;
    b. Semivolatile organic compounds (SVOCs);
    c. Other organic parameters;
    d. Unfiltered inorganic constituents (e.g., total metals);
    e. Filtered inorganic constituents (e.g., dissolved metals); and
    f. Other constituents

    Refer to the site-specific work plan for other parameters.

    During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and to maintain sample integrity.

2. VOC Sample Collection

    a. Samples for VOCs, volatile petroleum hydrocarbons (VPH) or gasoline range organics (GRO) will be collected first, and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

    b. When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases, 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Make a note of effervescence in the field book for future reference.

3. Non-VOC Sample Collection

    a. Completely fill the remaining sample containers for all non-VOC analyses.

    b. Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-

preserved. (NOTE: Pre-preserved vials may also be supplied by the laboratory depending on the program).

4. Filtering of Samples

    a. Depending upon project requirements, filtering may be performed using a portable peristaltic pump. See Section 2.2.4, step 3 for setting the flow rate of the pump.

       Samples may be filtered direct at the point of collection or collected into an intermediate sampling container and filtered on-shore.

    b. For direct collection and filtering, place the intake end of the tubing directly into the intermediate or temporary sample container (must be unpreserved) or directly into the body of water. The discharge end of the tubing is attached to the filtration unit.

       For filtering on-shore, collect the sample into the same sample container type to be used for the final sample bottle. Use a large volume size container or multiple sample containers for the pre-filter rinse.

    c. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the dedicated, disposable filter by allowing a minimum of 0.5 to 1 liter of surface water to pass through the filter prior to sampling and discard the pre-rinse liquid. Ensure the filter is free of air bubbles prior to collecting samples.

    d. Collect the filtered water directly from the tubing into an appropriately preserved container. Clearly note “filtered” or “dissolved” on the sample label and COC document.

    e. Change the tubing and filter after the collection of each sample.

2.3 Sediment Sampling Procedures

1. Determine the sampling device to be used from the site-specific work plan, the depth of water at the sampling location, and/or the physical characteristics of the sediment to be sampled.

2. Select a sample location that is representative of sediment depositional areas or in accordance with the site-specific work plan and sampling objectives. Examples include: a sandbar in the middle of a stream; the inside curve of a meandering stream; the down-flow side of a boulder; a deep pool where water velocities are reduced; directly upstream and downstream of an outfall; or a stream delta where the stream carrying the sediment reaches a body of standing water (i.e., pond, lake, ocean cove or bay) or another stream with lower flow velocity.

3. For sampling sediment using direct push procedures, refer to TRC’s RMD SOP 003, Soil Sampling.

4. The following steps are generally employed for all sediment samples, regardless of the sampling device used:

a. Collect a sample for VOCs, VPH, GRO and/or acid volatile sulfide (AVS)/simultaneously extracted metals (SEM) analysis, if required. If VOC, VPH or GRO analyses are required, collect the sample in accordance with the procedures in Attachment A or the site-specific work plan. For AVS/SEM analysis, immediately fill a sample container leaving no headspace.

b. Unrepresentative materials (e.g., leaves, stones) should be removed as much as practicable from the sample.

c. Transfer the sample into a homogenization bowl that has been decontaminated.

d. Decant the aqueous layer from the homogenization bowl prior to homogenization. Extra care should be taken to retain the fine-sediment fraction during the decanting process.

e. Homogenize the sample as quickly as possible prior to filling the sample containers by mixing the sample within the bowl using a stainless-steel spoon. The following order of collection should be followed for non-VOC parameters: SVOCs, extractable petroleum hydrocarbons (EPH), pesticides, polychlorinated biphenyls (PCBs), inorganics, geotechnical parameters, and biological parameters.

f. If samples will not be frozen by the laboratory, fill sample containers to the brim to reduce oxygen exposure.

2.3.1 Sampling Surface Sediment (i.e., 0-6" below ground surface [bgs]) with a Spade, Shovel, Trowel, or Scoop from Beneath a Shallow Aqueous Layer (i.e., 0-12" bgs)

This sample method is recommended only when in shallow slow-moving waters.

1. Using a decontaminated spade, shovel, trowel, or scoop, remove the sediment from the sampling area.
2. Proceed to Section 2.3, steps 4a through 4f.

2.3.2 Sampling Surface Sediment (i.e., 0-6" bgs) with a Bucket Auger or Tube Auger From Beneath a Shallow or Deep Aqueous Layer

Due to the small volume of many core samplers, multiple recoveries may be required to obtain the necessary volume.

1. If warranted due to project needs (i.e., maintain integrity of the intact sediment core), insert an acetate core into the bucket auger or tube auger prior to sampling.
2. Attach the auger head to the required length of extensions and attach a "T" handle to the upper extension.
3. Gently remove any visible surface debris from the area to be sampled once brought to the surface.
4. Insert the auger into the sediment at a 0º to 20º angle from vertical. The angle minimizes spillage of the sample from the auger upon extraction from the sediment and water.
5. Rotate the auger to cut a core of sediment.
6. Withdraw the auger slowly. If using a tube auger, be sure the slot is facing upward.

7. Proceed to Section 2.3, steps 4a through 4f.

2.3.3 Sampling Surface Sediment (i.e., 0-6" bgs) with an Eckman Dredge or Ponar Grab from Beneath a Shallow or Deep Aqueous Layer

2.3.3.1 Use of the Eckman Dredge (Preferred with Moderately Consolidated, Fine-Textured Sediment)

The Eckman dredge is not usable in sandy or rocky sediments of high velocity streams. If sampling from heights greater than 5 feet above the water table surface (i.e., bridge sampling), the spring mechanism may be damaged by the speed/impact of the messenger during the triggering of the trap doors.

1. Measure the depth of the water body using a decontaminated measuring tape, staff, or rod.
2. Attach the appropriate length of nylon rope or stainless-steel cable through the hole on the top of the dredge sampler bracket. Mark the distance to the bottom of the rope or cable.
3. Carefully attach springs to both sides of the jaws. Fix jaws so they are in the open position. Ensure the hinged doors on the dredge top are free to open.
4. Lower the sampler to within about 1 foot above the sediment surface.
5. Drop the sampler to the sediment.
6. Trigger the jaw release mechanism by sending the messenger down the rope or cable.
7. Raise the sampler and open top doors. Inspect the sample for acceptability as follows:
   - Ensure the sediment surface is not touching the top of the sampler. If it is, the sampler may be overfilled.
   - Ensure that overlying water is present. This indicates minimal leakage.
   - Ensure the desired depth of penetration has been achieved.
   - Ensure there are no signs of sediment loss via incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval.
   - If these inspections indicate an unacceptable sample, repeat procedures.
8. Proceed to Section 2.3, steps 4a through 4f.

2.3.3.2 Use of Ponar Grab (Preferred with Consolidated Fine-to-Coarse-Textured Sediment)

1. Measure the depth of the water body using a decontaminated measuring tape or staff.
2. Attach the appropriate length of nylon rope or stainless-steel cable to the ring on the top of the dredge. Mark the distance to the bottom of the rope or cable.
3. Fix jaws so they are in the open position.
4. Slowly lower sampler to within several feet above sediment.
5. Drop the sampler to the sediment. Pull up sharply on the line to close the dredge.
6. Raise the sampler and open dredge jaws. Inspect the sample for acceptability as follows:

- Ensure the sediment surface is not touching the top of the sampler. If it is, the sampler may be overfilled.
- Ensure that overlying water is present. This indicates minimal leakage.
- Ensure the sediment-water interface is intact and relatively flat with no sign of channeling or sample washout.
- Ensure the desired depth of penetration has been achieved.
- Ensure there are no signs of sediment loss via incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval.
- If these inspections indicate an unacceptable sample, repeat procedures.

7. Proceed to Section 2.3, steps 4a through 4f.

2.3.4 Sampling Sediment in Deep Water

2.3.4.1 Use of Vibracore

The vibracore is a long continuous tube that is driven into the sediment using vibrating action, typically with a pneumatic impactor. The entire core is withdrawn, at which point the entire sample can be extruded and subdivided, or the tube may be cut into segments for sample extraction later. The vibracore can be operated from a small floating plant or barge with a tripod or small derrick and winch to assist in raising and lowering. Vibracores are typically 2-4 inches in diameter and vary in lengths typically in 5-foot increments up to 20 feet long.

The vibracore is only suitable for unconsolidated sediments and cannot penetrate most coarse or consolidated materials. Cores can be equipped with a catcher or the tube can be driven into a layer of compacted material, which forms a "cap" at the bottom. The vibration of the tube has been known to consolidate the sample. The vertical integrity of vibracore samples may be disturbed. As a result, vibracores are well suited for the collection of samples to be vertically composited.

The sediment cores for environmental analysis are typically contained in the vibracore sections within clear, chemically-inert liners that can be cut into project-specified lengths, capped for transport, labeled for identification, and stored on ice until delivered to a shoreline work station for logging and sample collection; or shipped to a laboratory directly for logging and testing.

Proceed to Section 2.3, steps 4a through 4f.

2.3.4.2 Use of Split-Spoon Sampler

The split-spoon sampler is used for subsurface sampling of unconsolidated materials that are both saturated and unsaturated, and can be used for sediment sampling.

The sampler is a metal cylinder which is divided in half, lengthwise. The two halves of the spoon are held together by small pieces of threaded pipe at each end. An open cap, with a catcher is screwed on the tip. The sampler is attached to lengths of steel rod and driven into the sediments with a hammer or weight. After the sampler is withdrawn, the front and rear end pieces are unscrewed, the sampler opened, and the sample removed with a spoon. Be sure to record the recovered sediment in inches into the field book and collect any chemical and biological samples prior to logging the physical characteristics of the recovered sediment.

Split-spoon samplers can be used for most types of sediments, including consolidated sand and clay. Recovery is variable, sometimes poorer with soft, fine-grained sediments. Split-spoon samplers are typically 2-3 inches in diameter, and available in lengths from 2-5 feet. Successive vertical samples can be taken by driving casing (typically a 5-inch pipe) and cleaning out the drill hole between samples. The vertical integrity of an individual split-spoon sample is variable, but a vertically composited sample can be obtained between two elevations with accuracy.

Proceed to Section 2.3, steps 4a through 4f.

2.4 Post-sampling Activities

1. After the samples have been collected, it is preferable to record the sampling location with a GPS device. Alternatively, the in-water sampling location and/or adjacent shoreline location may be marked with wooden stakes colored with highly visible spray paint or flagging in order to identify the sample location for surveying purposes, and/or buoys with unique sample identification numbers (for deeper water locations). The sample and/or location identification should be written on the stake in indelible ink or marking pen. The fixed sampling point should be located with a measuring tape relative to three nearby fixed reference points.

   Record this information on the field map and field book (with sketch) in addition to collecting the GPS or triangulation data. A photograph of the sample location and a field record of water conditions at the time of sampling is also recommended.

2. If required, the temperature, pH, DO, oxidation-reduction potential, conductivity, and/or turbidity of the surface water should be determined immediately after sample collection. Where possible, field measurements of these parameters should be measured in-situ, rather than from a sample container. These measurements should not be taken from any sample bottles being sent to the analytical laboratory for chemical analysis.

3. Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOC vials.

4. Package the samples with bubble wrap and/or organic absorbent, as necessary.

5. Place the samples into a shipping container and cool to 4ºC. If wet ice is used to cool the samples, place the ice in double Zip-loc® bags to prevent water from the melting ice from damaging the samples during shipment.

6. Complete the COC form.

7. Decontaminate non-disposable sampling equipment between uses.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following samples: equipment blank, trip blank, field duplicate, and matrix spike/matrix spike duplicates.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of surface water and sediment samples:

a. For QC purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for sediment and surface water sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book.

b. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC, VPH and/or GRO containers are filled and sealed, the duplicate sample VOC, VPH and/or GRO containers will also be filled and sealed. For sediment samples, duplicates for all parameters other than VOCs, VPH and GRO should be filled from the homogenized sample to ensure consistency between the sample and the duplicate. Following the order of collection specified for each set of containers (i.e., VOCs, VPH, GRO, SVOCs, other organics and then inorganic constituents), the duplicate sample containers will be filled simultaneously with the actual sample for each parameter.

c. All collection and preservation procedures outlined for surface water and sediment sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is poured over the decontaminated equipment (if applicable) and collected and preserved in the same sample containers as surface water samples. Note: Equipment blanks associated with sediment samples are collected and preserved in the same sample containers as surface water samples. If sampling surface water using the direct-fill method, equipment blanks are not required. However, if filtering is performed, an equipment blank could be performed to demonstrate the filtration equipment is clean.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will check for potential contamination of samples by VOCs via migration during storage and shipping. For surface water samples, trip blanks consist of two to three 40-mL VOA vials filled with analyte-free water and preserved with hydrochloric acid to pH <2 SU. For sediment samples, trip blanks consist of the same number of water-preserved and/or methanol-preserved vials as used for field samples. Trip blanks are submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 Matrix Spikes/Matrix Spike Duplicates (MS/MSDs) and MS/Duplicates

Matrix spikes (MSs) are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. Matrix spike duplicates (MSDs) are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

For surface water samples, triplicate volume of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. An additional volume of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. Generally, extra volume will not be required to be collected for sediment MS/MSD or MS/Duplicate analyses. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the comments column of the COC document.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with umpreserved water (potable or distilled) and are sometimes included in all coolers which contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process. The container for the temperature blank must be clearly labeled "Temperature Blank."

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the general sample collection information such as location, identification, and date/time in the field book or on a sample log sheet. Unless not prescribed in the site-specific work plan or if different from the site-specific work plan, typical field documentation recorded in a field book includes the following information:

- Sample identification number
- Sample location (description or sketch of the sample point)
- Sample depth interval
- GPS coordinates and coordinate system
- Time and date sample was collected
- Type of sampling equipment used
- Personnel performing the task
- Water depth and depth of sample penetration
- Water descriptions (e.g., clarity, flow, foam, debris)
- Visual or other sensory description of the sample (e.g., odors, staining)
- Sediment descriptions (e.g., color, texture, appearance)
- Estimate of sediment quantity recovered by grab sampler
- Weather conditions during sampling
- Other pertinent observations, including whether photographs were taken
- Sample collection equipment used
- Water field parameters such as pH, temperature, conductivity, turbidity, oxidation-reduction potential, and DO
- Decontamination procedure
- Analytical parameters
- Preservation method
- Water quality monitoring equipment calibration information
- Field duplicate location

Affix a properly completed label to each sample container.

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the site-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

Great Lakes Dredged Material Testing and Evaluation Manual, Appendix D, Sediment Sampling & Handling Guidance, EPA Region 5, September 30, 1998.

Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. EPA-823-B-01-002. Office of Water. October 2001.

Method for the Determination of Volatile Petroleum Hydrocarbons (VPH). MassDEP. May 2004.

SW-846 Method 5035A, *Closed-system Purge-and-trap and Extraction for Volatile Organics in Soil and Waste Samples.* USEPA. Draft Revision 1, July 2002.

40 CFR Part 136. Guidelines Establishing Test Procedures for the Analysis of Pollutants. USEPA.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	APRIL 2014	NOT APPLICABLE

Attachment A:

Procedure for Collection of Sediment Samples for VOCs, VPH or GRO (SW-846 Method 5035A)

1.0 SAMPLING FOR VOLATILE ORGANIC COMPOUNDS IN SEDIMENT BY EPA METHOD 5035/5035A

The following sampling protocol is recommended for site investigations assessing the extent of VOCs (including VPH and GRO) in sediment at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the required detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

SW-846 Method 5035 provides instructions and options on the preservation of sediment samples for low-level and high-level VOC analyses:

- Low-level (≤ 200 µg/kg) and
- High-level (> 200 µg/kg).

The choice of low-level or high-level analysis is determined by the requirements of the project. However, since the low-level method is only valid for a certain concentration range, a sample for analysis by the high-level method must also be collected to ensure quantification of all target analytes is possible, if needed.

The low-level method uses one or more of the following options for the sampling/preservation of sediment:

- Sediment sampled into a vial with a sodium bisulfate ($NaHSO_4$) solution.
- Sediment collected in an En-Core® sampler and immediately shipped to the laboratory for further preservation (within 48 hours).
- Sediment collected in a vial with organic-free water, sealed in the field, and shipped to the laboratory immediately in order to meet the method preservation requirement to freeze within 48 hours of collection.

Based on project-specific requirements, trip blanks may be recommended. Refer to the site-specific work plan for quality assurance (QA)/QC requirements.

1.1 Low-level Method (VOCs)

Option A - Direct sampling into En-Core® samplers

- Three 5 gram size En-Core® samplers for each sample.
- One non-preserved container for moisture determination.

Option B - Direct sampling into vial with chemical preservative

- Two 5 gram size cores are added to volatile organic analysis (VOA) vials (one core is added to each of two VOA vials with sodium bisulfate solution) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). Once the vials are sealed in the field, these are not opened again.
- One non-preserved container for moisture determination.

Option C - Direct sampling into vial with water (to be frozen at the laboratory)

- Two 5 gram size cores are added to VOA vials (one core is added to each of two VOA vials with water) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). Once the vials are sealed in the field, these are not opened again.
- One non-preserved container for moisture determination.

1.2 High-level Method (VOC, VPH, GRO)

Option D - Direct sampling into En-Core® samplers

- One 5 gram size En-Core® sampler for each sample.
- One non-preserved container for moisture determination.

Option E - Direct sampling into a methanol-preserved vial

- For VOCs: 5 or 10 grams of sediment is added to a VOA vial (with 5 or 10 grams of methanol, respectively) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). This may also depend upon the regulatory agency (e.g., New Jersey Department of Environmental Protection requires 8 to 12 grams in 25 mL methanol or 5 grams in 10 mL methanol).
- For VPH or GRO: The coring device will be filled with 25 grams of undisturbed sediment if 60-ml vials with 25 ml of methanol are used, or 15 grams of undisturbed sediment if 40-ml vials with 15 ml of methanol are used. The goal is to have a 1:1 ratio of sediment-to-methanol.
- One non-preserved container for moisture determination.

1.3 Cautions and Potential Problems

1. Potential leaking sample containers for VOC, VPH and GRO analyses:

   Options for evaluating containers for leaking preservatives:

   a. When ordering pre-preserved sample containers, laboratories should be encouraged to mark the meniscus of the preservative on all sample containers. The preservative level should be checked before sampling as a quick check that there has not been any loss of liquid.
   b. Compare preservative level in multiple bottles and select one for comparison purposes to subsequent sample bottles.
   c. Weigh methanol-preserved sample containers prior to sampling. Sample containers found to have lost greater than 0.2 grams of methanol compared to their initial weight should not be used. In order to perform this option, initial container weights must be provided by the laboratory.

2. Potential methanol absorption:

   Sediment may be encountered that absorbs all of the methanol preservative (e.g., organic-rich sediment, fine-grain sediment). These sediments can absorb the methanol leaving no methanol extract for the laboratory to analyze. In these instances, the use of additional methanol is required. The laboratory must be contacted for sample containers with an increased volume of methanol. Using a 1:2 ratio of sediment-to-methanol will help to ensure that there will be adequate volume of methanol remaining for analysis. **NOTE: Additional methanol should not be added to the sample container by the sampler in the field. Containers with additional methanol must be obtained from the laboratory.**

3. Collection of samples with high moisture content:

   Sediment samples with high (>50%) moisture content may prevent the attainment of the ideal 1:1 sediment-to-preservative ratio. In these instances, depending on the data quality objectives, it may be necessary to evaluate the sediment to determine what level in the disposable syringe corresponds to the required weight (typically 5 grams for VOCs and 15 or 25 grams for VPH). This can be performed by collecting several trial samples with disposable syringes. Weigh each trial sample and note the length of the sediment in the syringe. These measurements would be used to determine how much sediment in the syringe corresponds to 5 $\pm$ 0.5 grams (or the desired weight $\pm$ 0.5). All trial samples should be discarded and not used for analysis.

4. En-Core® sampler cautions:

   a. En-Core® samplers, or equivalent, should only be used on fine-grain or cohesive sediments (sediments that stay together in the En-Core® sampler and do not fall apart). En-Core® samplers should not be used to collect sediment samples with high moisture (e.g., sediments below the water table). In the case of sediment samples with high moisture (e.g., sediments below the water table), a stainless steel spatula or scoop should be used with field preservation techniques.
   b. The En-Core® sampler is a single-use device and cannot be decontaminated and reused.
   c. The volume of material collected in an En-Core® sampler should not cause excessive stress on the coring tool.
   d. The volume of material collected should not be so large that the sample easily falls apart during extrusion.
   e. The En-Core® sampler should not be used if any of the components are damaged as the seals may be compromised. Under no circumstances should any components be removed or disturbed.
   f. It is important to make sure air is not trapped behind the sample, as this could cause air to pass through the sample, resulting in a loss of VOCs, or it could cause the sample to be pushed prematurely from the coring tool.

5. Potential effervescence with use of sodium bisulfate as a preservative for low-level VOC analysis of sediments.

   This method of preservation is not preferred and, therefore, is not outlined below. If it is used, the following cautions exist:

   a. Carbonaceous or strongly alkaline sediments may cause potential effervescence when reacting with the sodium bisulfate and may result in a loss of VOCs and a shattered vial. If effervescence occurs, sodium bisulfate should not be used. The laboratory must be contacted and low-level preservation techniques, using water only, should be followed.
   b. Loamy materials or materials containing decayed material may result in false positive results for acetone due to the interaction with the sodium bisulfate.

c. Some VOCs may be lost due to the resulting acidification when sodium bisulfate is used (e.g., styrene, 2-chloroethyl vinyl ether, acrylonitrile).
d. Some VOCs may be lost if the laboratory is using a heated purge in combination with the sodium bisulfate preservative (e.g., methyl tert butyl ether [MTBE] and other fuel oxygenates).

1.4 Sample Containers and VOC Sampling Equipment

- Method 5035A-compatible containers or kits (for VOCs, VPH and GRO). Preservatives may be required for some samples with certain variations of SW-846 method 5035A – consult the governing regulatory agency or principal analytical chemist to determine which preservatives are necessary.
  - Low-level VOCs: two 40-mL VOA vials pre-preserved with 5 mL organic-free water and also containing a magnetic stir bar.
  - High-level (or medium-level) VOCs: one 40-mL VOA vial pre-preserved with 5 or 10 mL of purge-and-trap-grade methanol. Volume will be dependent upon laboratory's preference or regulatory agency requirements (e.g., New Jersey Department of Environmental Protection prefers vials with 10 or 25 mL of purge-and-trap-grade methanol).
  - VPH and GRO: One 60-mL vial pre-preserved with 25 mL of purge-and-trap-grade methanol **or** One 40-mL VOA vial pre-preserved with 15 mL of purge-and-trap-grade methanol

  and
  - One glass container (or other appropriate container) with no preservative to allow the laboratory to perform the percent solids measurement. NOTE: The laboratory typically requires a minimum of 20 grams to perform this test. Therefore, submitting a sample size less than 4 ounces may be acceptable. This additional container will not be required if the sample is also being submitted for other non-VOC parameters.

- En-Core® samplers, or equivalent, for VOC, VPH and/or GRO analysis:
  - High-level VOC or GRO analysis: one 5-gram En-Core® sampler.
  - Low-level VOC analysis: two 5-gram En-Core® samplers.
  - VPH, GRO or toxicity characteristic leaching procedure (TCLP) VOC analysis: one 25-gram En-Core® sampler.

- Disposable plastic syringes or Terra Core™ samplers.
- Foam VOC vial holders.
- Portable digital scale (accurate to ± 0.01 grams) with calibration weights.

2.0 COLLECTION OF SAMPLES USING EN-CORE® SAMPLERS, OR EQUIVALENT

- The sample will be collected using an En-Core® sampler, or equivalent, as soon as possible after the sediment has been exposed to the atmosphere.
- Check that the En-Core® sampler, or equivalent, is full using both of the following procedures:

a. Be sure that the back o-ring on the plunger can be seen when looking through the viewing hole on the handle. This will mean that the sediment has pushed the plunger fully to the back.

b. The plunger can only be rotated when it is fully pushed to the back of the body. Therefore, it is important to twist the plunger to guarantee that the sediment has filled the sampler and the back o-rings have sealed.

- Immediately seal the En-Core® sampler, or equivalent. Be sure to twist the cap as it is pushed on. The cap is properly sealed when the two locking arms are completely and symmetrically over the body ridge.
- The samples must be shipped to a laboratory within 24 hours of sampling to ensure the 48-hour hold time for preservation will be met.
- In the event that a field screening technique (instrument reading or visual staining of the sediment) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.
- If samples are collected for only VOC and VPH analyses, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

3.0 COLLECTION OF SAMPLES USING FIELD PRESERVATION

- Samples for VOCs will be collected as soon as possible after the sediment has been exposed to the atmosphere.
- Samples for VOCs will be collected first (prior to collection of samples for other parameters) using an open-barrel disposable syringe, Terra Core™ sampler, or equivalent. In the case of samples with high moisture (e.g., sediments below the water table), an open-barrel disposable syringe may not be practical; a stainless steel spatula or scoop can be used with field preservation techniques.
- Sediment samples for VOC analyses should **never** be homogenized.
- Each pre-preserved sample container will be weighed prior to sample collection, and the container/preservative weight will be recorded. This procedure will generally be performed by the laboratory prior to shipping the containers to the field.
- Depending upon project requirements, samples for VOC analysis will be collected as low-level, high-level, or both.

- **<u>Low-level VOCs</u>**

1. The syringe will be filled with undisturbed sediment of the following volume: 5 grams of sediment.

   As an option to the syringes, 5-gram Terra Core™ samplers, or equivalent, can be used. The goal is to have a 1:1 ratio of sediment-to-preservative.

2. The sediment will be extruded into a pre-preserved VOA vial containing a magnetic stir bar and 5 mL reagent-grade water. This will be done in replicate.

3. Any sand grains present on the container rim or cap must be removed to ensure an air-tight seal of the vial. The VOA vial will be capped quickly and labeled with the sample ID, date, and time of collection. Labels should not be written on the cap of the vial.
4. Gently swirl sample to break up the sediment aggregate, if necessary, until the sediment is covered with preservative. It is imperative that the sediment sample be completely immersed in the preservative solution.
5. In the event that a field screening technique (instrument reading or visual staining of the sediment) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.
6. If samples are collected for only VOC analysis, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

- **High-level VOCs, VPH, or GRO**

1. High-level VOCs: The syringe will be filled with undisturbed sediment of the following volume: 5 or 10 grams of sediment for high-level analysis (added to the 5 or 10 ml of methanol, respectively). This may also depend upon the regulatory agency (e.g., New Jersey Department of Environmental Protection requires 8 to 12 grams in 25 mL methanol or 5 grams in 10 mL methanol).

   VPH or GRO: The syringe will be filled with 25 grams of undisturbed sediment if 60-ml vials with 25 ml of methanol are used, or 15 grams of undisturbed sediment if 40-ml vials with 15 ml of methanol are used. The goal is to have a 1:1 ratio of sediment-to-methanol.

   As an option to the syringes, 5-gram Terra Core™ samplers, or equivalent, can be used. Typically, the goal is to have a 1:1 ratio of sediment-to-preservative.
2. The sample will be extruded into a VOA vial containing purge-and-trap grade methanol
3. Any sand grains present on the container rim or cap must be removed to ensure an air-tight seal of the vial. The VOA vial will be capped quickly and labeled with the sample ID, date, and time of collection. Labels should not be written on the cap of the vial.
4. Gently swirl sample to break up the sediment aggregate, if necessary, until the sediment is covered with preservative. It is imperative that the sediment sample be completely immersed in the preservative solution.
5. In the event that a field screening technique (instrument reading or visual staining of the sediment) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.
6. Methanol is considered to be a hazardous material by the US Department of Transportation (DOT) and the International Air Transportation Association (IATA). Shipments containing methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the most current edition of the IATA Dangerous Goods Regulations. The volumes of methanol recommended in the VOC method fall under the small quantity exemption of 49 CFR section 173.4. Refer to Attachment C for further details.
7. If samples are collected for only VOC analysis, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

Attachment B:

Example Surface Water/Sediment Sample Log

TRC Surface Water/Sediment Sample Log	Project:	Project No.:	Date/Time:	Sheet __ of __
	Contractor Personnel:		TRC Personnel:	

Sample No.: ____________________

Depth/Interval Sampled: ______________

Sample Type: (circle) Grab Composite Both

Media: (circle) Other ________ Sediment Surface Water

Water Depth: _________

Field Screening Information:

Type of Meter:

Sketch of Sample Location

Other Field Measurements:

Sample Description/Observations:

SAMPLE COLLECTION EQUIPMENT

Hand Auger	☐	Dip Sampler	☐
Core Sampler	☐	Trowel	☐
Spatula/Spoon	☐	Dredge Sampler	☐
Bowl (stainless)	☐	Kemmerer	☐
En-Core®	☐	Extension Rods	☐
Tube Auger	☐	Van Dorn Bottle	☐
Direct	☐	Spade	☐
Ponar Grab	☐	Shovel	☐
Bucket Auger	☐	Terra Core™	☐
Peristaltic Pump	☐	Scoop	☐
Macro-Core®	☐	Vibracore	☐
Other	☐	Split-spoon	☐

Analytical Parameters	Filtered (circle)		Preservation Method	Volume/Container	Time of Collection	Sample ID
	YES	NO				
	YES	NO				
	YES	NO				
	YES	NO				
	YES	NO				
	YES	NO				

Signed: ____________________

L2013-386 November 2013

Attachment C:

Shipping Methanol-preserved Samples

Shipping of Hazardous Materials

Methanol is considered a hazardous material by the US Department of Transportation (DOT) and the International Air Transport Association (IATA). Shipments of methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the most current edition of the IATA Dangerous Goods Regulations. Consult these documents or your shipping company for complete details.

Small Quantity Exemption

The volumes of methanol recommended in the high-level VOC, VPH and GRO methods fall under the small quantity exemption of 49 CFR section 173.4. To qualify for this exemption, all of the following conditions must be met:

◊ the maximum volume of methanol in each sample container must not exceed 30 mL
◊ the sample container must not be full of methanol
◊ the sample container must be securely packed and cushioned in an upright position and be surrounded by a sorbent material capable of absorbing spills from leaks or breakage of sample containers
◊ the package weight must not exceed 64 pounds
◊ the volume of methanol per shipping container must not exceed 500 mL
◊ the packaging and shipping container must be strong enough to hold up to the intended use
◊ the package must not be opened or altered while in transit
◊ the shipper must mark the shipping container as follows:

“*This package conforms to 49 CFR 173.4*”

When shipping domestically by Federal Express via ground or air, the following rules apply:

◊ follow the inner packaging requirements of 49 CFR 173.4
◊ no labels, placards, up arrows, or dangerous goods shipping papers are required
◊ if the Federal Express airbill has a shipper’s declaration for hazardous goods on it, check the Yes box under *Shipper’s Declaration not Required*

When shipping internationally by Federal Express, the following rules apply:

◊ follow the inner packaging requirements of 49 CFR 173.4
◊ use dangerous goods shipping papers
◊ apply orientation arrows on opposite vertical sides on the exterior of the package

Shipping Papers for International Shipments

International shipments must be accompanied by dangerous goods shipping papers that include the following:

Proper Shipping Name:	Methyl Alcohol
Hazardous Class:	Flammable Liquid
Identification Number:	UN1230
Total Quantity:	*(mL methanol/container x the number of containers)*
Emergency Response Info:	Methanol MSDS attached
Emergency Response Phone:	1-800-424-9300

Attachment D:

SOP Fact Sheet

SURFACE WATER AND SEDIMENT SAMPLING

PURPOSE AND OBJECTIVE

The objective of surface water and sediment sampling is to obtain a representative sample for analysis of physical and/or chemical parameters, as necessary, at a given site. This objective requires that the sample be both free of unsuitable material and be of sufficient quantity and quality for analysis by the selected analytical method. Surface water and sediment samples are collected either directly using a hand-held device or indirectly using a remotely activated device.

WHAT TO BRING: GENERAL EQUIPMENT

- Site-specific HASP
- Appropriate PPE
- Rubber boots and/or hip/chest waders
- Figure showing sample locations
- Field book and/or Sample Log Form
- Indelible marking pens or markers
- Tape measure, folding ruler and or calibrated staff
- Camera
- Compass
- Boat (if needed) with anchor
- Buoys
- Thermometer and/or Barometer
- Zip-loc® plastic bags
- Organic absorbent (e.g., Slickwick, sawdust)
- Bubble wrap
- 5-gallon bucket(s)
- Lint-free, non-abrasive, disposable towels
- Calibrated PID or FID
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags
- Survey equipment and/or GPS and/or other means of establishing sample locations
- Equipment decontamination supplies
- Sample bottleware, labels, coolers, ice, and blank COC forms; may also need field blank bottles and reagent-grade water

WHAT TO BRING: SURFACE WATER SAMPLING EQUIPMENT

- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, oxidation-reduction potential, and DO). Note: Salinity probe may be needed depending on project requirements
- Turbidity meter
- Sample collection tools (e.g., Dip sampler, Kemmerer bottle, Van Doren sampler, peristaltic pump)
- Teflon, Teflon–lined polyethylene, or HDPE tubing, dependent upon project objectives
- Filtration equipment, if required (peristaltic pump and 0.45 micron filters, or as otherwise required for the project)
- Graduated cylinder or five-gallon bucket
- Stop watch

WHAT TO BRING: SEDIMENT SAMPLING EQUIPMENT

- Sample collection tools (e.g., stainless steel or plastic spade, shovel, scoop, or trowel; hand or bucket auger with appropriate head and extension rods; sediment coring device [e.g., vibracore, gravity core, etc.]; ponar or equivalent grab samplers, eckman dredge)
- Nylon rope or stainless-steel cable (for dredges)
- Nylon tube brush
- Wire brush for thread cleaning
- Stainless-steel mixing bowl or disposable aluminum tray
- Stainless-steel spatulas or spoons
- Small scale to measure sample mass
- Dedicated Teflon® spoons (if required)
- En-Core® samplers, Terra Core™ samplers, or disposable plastic syringes

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the latest version.
- Discuss the objective for the sediment sampling program with the Project Manager and/or the field team leader. Discuss sample order, collection method, designation, analytical parameters, turn-around times, laboratory, etc.
  - Are sediment/purge water to be containerized or returned to source?
  - Volume requirements for each sample?
  - QC sample collection?
  - Field decontamination required?
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure, test equipment and make sure it is in proper working order.
- Review sample bottle order for accuracy and completeness.

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SURFACE WATER AND SEDIMENT SAMPLING

ON-SITE

- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Make sure appropriate PPE is worn by all personnel and work area is safe, including additional safety gear for working in or near water (e.g., harness, life jacket, tether, flotation device, etc.).
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.
- If both sediment and water samples are to be collected concurrently, each water sample should be taken prior to the corresponding sediment sample in order to avoid introducing sediment into the water column from sediment collection activities.
- Depth to the bottom must be accurately known in order not to disturb sediment during surface water collection. If water depth is unknown or not observed, use a calibrated rod, tape, or line to measure the depth to the bottom or refer to a known bathymetric survey if possible.
- In flowing streams or runoff channels, water and sediment samples should be collected first from the furthest point downstream (with each water sample collected before the sediment sample). The remaining samples will be taken while proceeding upstream.

SURFACE WATER SAMPLING

- Determine the sampling device to be used from the site-specific work plan and/or the depth of water at the sampling location.
- Select a sample location in accordance with the site-specific work plan and sampling objectives. Record sample location using a GPS device, or reference a fixed onsite reference point, wooden stake or buoy.
- Collect surface water samples in the following order:
  - VOCs;
  - SVOCs;
  - Other organic parameters;
  - Unfiltered inorganic constituents; and
  - Filtered inorganic constituents.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.2.5(2) of SOP.
- Preserve the non-VOC samples in pre-preserved vials supplied by the laboratory or if the sample containers are not pre-preserved, preserve the non-VOC samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed using a portable peristaltic pump. See procedures listed in Section 2.2.5(4). Clearly note "filtered" on the sample label and the COC.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment between uses.

SEDIMENT SAMPLING

- Determine the sampling device to be used from the site-specific work plan, the depth of water at the sampling location, and/or the physical characteristics of the sediment to be sampled.
- Select a sample location that is representative of sediment depositional areas or in accordance with the site-specific work plan and sampling objectives. Record sample location using a GPS device, or reference a fixed onsite reference point, wooden stake or buoy.
- First, collect a sample for VOCs, VPH, GRO and/or AVS/SEM analysis, if required. If VOC, VPH or GRO analyses are required, collect the sample in accordance with the procedures in Attachment A or the site-specific work plan. For AVS/SEM analysis, immediately fill a sample container leaving no headspace.
- Unrepresentative materials (e.g., leaves, stones) should be removed as much as practicable from the sample.
- Transfer the remaining sample into a homogenization bowl that has been decontaminated.
- Decant the aqueous layer from the homogenization bowl prior to homogenization. (Extra care should be taken to retain the fine-sediment fraction during the decanting process).
- Homogenize the sample as quickly as possible prior to filling the sample containers by mixing the sample within the bowl using a stainless-steel spoon. The following order of collection should be followed for non-VOC parameters: SVOCs, EPH, pesticides, PCBs, inorganics, geotechnical parameters, and biological parameters. If samples will not be frozen by the laboratory, fill sample containers to the brim to reduce oxygen exposure.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment before using at a different sampling location.

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SURFACE WATER AND SEDIMENT SAMPLING

DOs AND DO NOTs OF SEDIMENT AND SURFACE WATER SAMPLING

DOs:

- DO have the following items when going into the field:
  - Site-specific work plan
  - Site-specific HASP
  - PPE (e.g. steel-toed boots, gloves)
  - Field book and indelible ink ball-point pens or markers
- DO proceed from downstream locations to upstream locations.
- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled to ensure timely sample collection.
- DO fill sample bottles slowly to make sure that they are not overfilled and that preservative does not become diluted. If collecting filtered samples, fill all non-filtered samples first, then fill filtered samples - if water is very silty, more than one filter might be required to fill sample bottles.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them.
- DO have the numbers for the laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO record sample locations in the field book as you sample.
- DO check on the sample setup frequently to make sure proper equipment function is maintained.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

DO NOTs:

- DO NOT collect sediment samples prior to surface water samples, if samples are to be collected concurrently. Each water sample should be taken prior to the corresponding sediment sample in order to avoid introducing sediment into the water column from sediment collection activities.
- DO NOT allow surface water sampling equipment to stir the bed of the water body you are sampling. If the sampling device contacts the bottom, it can stir up sediment which affects the analysis of surface water quality.
- DO NOT homogenize sediment samples for VOC analyses.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

Title: **Calibration of Field Instruments for Water Quality Parameters**	Procedure Number: **RMD 011**
	Revision Number: **0**
	Effective Date: **November 2014**

Authorization Signatures

Darby Litz		Elizabeth Denly	
Technical Review	Date	Remediation Practice Quality Coordinator	Date
Darby Litz	11/21/2014	Elizabeth Denly	11/21/14

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for ground water and surface water. Water quality instruments addressed in this SOP include those that measure temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, oxidation-reduction potential (ORP), and turbidity.

1.2 Summary of Method

All monitoring instruments must be calibrated before they are used to measure environmental samples. This SOP outlines the general methods for field instrument calibration, calibration documentation requirements, and corrective action procedures that will be implemented during field activities. Calibration procedures are different for each field instrument used and these procedures should be provided by the instrument manufacturer. The manufacturer's instruction manual (including the instrument specifications) should accompany the instrument into the field.

At a minimum, calibration and/or a calibration check must be performed at the beginning of each day prior to use. Site-specific work plans should be consulted for required calibration frequency. Note: The initial calibration may be performed in the office prior to the field event or by the equipment supplier; however, calibration checks should be performed on site prior to use on the day of the fieldwork.

1.3 Equipment

The following equipment may be utilized when calibrating water quality parameter measuring equipment. Project-specific conditions or laboratory requirements may warrant the addition or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP).
- Water quality meter capable of measuring one or more of the following based on project scope: pH, temperature, DO, specific conductivity, and ORP (e.g., YSI 600XL, Horiba U-50, Hydrolab Quanta/QED MP-20, or equivalent)
- Turbidity meter (e.g., LaMotte Model 2020e, Hach 2100P, or equivalent)
- Deionized water
- Flow-through cell
- Ring stand with clamp
- Paper towels
- Soft tissue (e.g., Kimwipes®)
- Cuvettes

- Buffer solutions at pH 4, 7 and 10 standard units (SU)*. Commercially available solutions that have been validated by comparison to National Institute of Standards and Technology (NIST) standards are recommended for routine use.
- Conductivity solution (potassium chloride, typically 1,413 micromhos/centimeter [µmhos/cm])*
- ORP calibration solution (e.g., Zobell)*
- Turbidity standards (0, 1, 10 nephelometric turbidity units [NTUs] or StablCal Kit)*
- Zero DO solution (0.0 milligrams per liter [mg/L])*
- DO membrane kit (electrolyte solution, membranes)
- NIST thermometer (0.2ºC accuracy)*
- Small glass or polyethylene jars to hold the calibration standards (4-8 oz.)
- Field book
- Field instrument calibration logs
- Cup or spray bottle for the deionized water

*Dependent on the project-specific requirements and the instrument manufacturer

1.4 Definitions

Not applicable

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Implementing this SOP will require the use of calibration solutions. The following health and safety precautions must be taken with the pH, conductivity, turbidity, zero DO and ORP solutions: Avoid inhalation, skin and eye contact, and ingestion.

Maintenance of the instruments will require the use of liquid cleaners. Although these substances are not hazardous materials, TRC will appropriately handle and store them at all times in accordance with manufacturer's instructions.

1.6 Cautions and Potential Problems

General cautions and potential problems are discussed below. Specific issues for individual parameters are discussed in Section 2.

- Prior to calibration, all instrument probes must be cleaned according to the manufacturer's instructions. Failure to perform this step (proper maintenance) can lead to erroneous measurements. Rental instruments are routinely maintained by the vendor but should be checked for residues upon receipt.

- Prior to using calibration standards, check and record all expiration dates and lot numbers for the solutions on the field instrument calibration log. Discard any calibration standards that are past their expiration date.

- Avoid storing calibration solutions in extremely hot or cold temperatures to maintain solution integrity and prevent calibration errors.

- The volume of the calibration solutions must be sufficient to cover both the probe being calibrated and the temperature sensor (see manufacturer's instructions for additional information).

- Pre-rinse the sensor and calibration cup with a small amount of calibration solution to minimize dilution or cross-contamination.

- If desired, use a ring stand and clamp to secure the sonde in an upright position. This will prevent the sonde from falling over and damaging the probes.

- While calibrating or performing sample measurements, make sure there are no air bubbles lodged between the probe and the probe guard.

- Do not immerse the sensors in sea water or other highly saline water, alcohol or organic solvents.

- Problems during calibration may indicate the need to clean or replace sensors, electrodes or membranes or replace the calibration solutions.

- Have several clean absorbent paper towels or cotton cloths available to dry the probe between rinses and calibration solutions. Shake excess water off of the probes and dry off the outside of the probe sensors.

- All meters may have different relative accuracy, which will be specified in the instrument manual. Confirm that the meter being used meets the project's accuracy requirements.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Prior to use, instruments that will be used during field activities will be inspected to ensure they are clean, checked for possible malfunctions, and calibrated in accordance with manufacturer's procedures. Often, equipment provided by a rental company is calibrated prior to shipment, and a calibration certificate is provided with the equipment. Review the calibration certificate provided by the equipment supplier.

Calibration checks (or verifying that instrument readings fall within an acceptable range of a standard without running through the full instrument calibration steps) will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of faulty readings or instrument malfunction occurs. Some instruments or certain project scopes may require more frequent calibration checks depending on project quality objectives. In general, instrument selection and calibration will include the following steps:

- Determine which instruments are needed for the specific field tasks. Record the make, model number, and serial number of the instrument on the field instrument calibration log or in the field book.
- Obtain the necessary instruments and standard solutions for calibration. Check expiration dates on standard solutions and replace if out of date. Record the manufacturer, true value, lot number and expiration date of the standard solutions on the field instrument calibration log or in the field book.
- Assemble the instrument and turn it on allowing the instrument to warm up.
- Check battery charge, and charge or replace if necessary.
- Clean instrument (if necessary).
- If applicable, program the multi-probe instrument so that the applicable parameters to be measured will be displayed.
- Calibrate the instrument prior to field use in accordance with manufacturer's procedures. (Note: If applicable, calibrate DO and conductivity first, because these parameters may affect the other calibrations).
- Document all calibration activities and results on the field instrument calibration log or in the field book.
- If the instrument malfunctions and cannot be corrected, obtain a replacement.
- Clean and decontaminate the instrument after use and before storage.
- Conduct calibration checks at least once per day or as needed.

The subsections that follow provide additional details and guidance regarding calibration for specific parameters; however, since every field instrument is different, refer to the specific instrument's manual for appropriate operating and calibration procedures.

2.1 Temperature

Most instrument manuals state that calibration of the temperature sensor is not required, but this SOP recommends that the temperature sensor be checked to verify its accuracy. This accuracy check should be performed at least once per year and the accuracy check date/information should be kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was performed over a year prior to the date of use, it is recommended that the temperature sensor accuracy be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor should be checked. Accuracy checks may be performed by the manufacturer/equipment supplier or in the field. Review the calibration certificate provided by the equipment supplier.

In the event of suspect temperature readings, the following verification procedure can be performed.

FIELD VERIFICATION PROCEDURE

1. Record the manufacturer, model number, and the certification number of the NIST thermometer being used to check the instrument's temperature sensor on the field instrument calibration log or in the field book. Allow a container filled with water to equilibrate to ambient temperature.

2. Place an NIST thermometer and the instrument's temperature sensor into the water, and wait approximately 2 to 3 minutes for both temperature readings to stabilize.

3. Record the temperature displayed by the thermometer and the temperature sensor on the field instrument calibration log or in the field book.

4. Compare the two measurements. The instrument's temperature sensor must agree with the NIST thermometer measurement within the accuracy of the sensor (typically $\pm$0.15ºC). If the measurements do not agree, determine the correction factor to be applied to any subsequent temperature measurements made with this instrument. This correction factor must be applied to all readings made with the temperature sensor of this instrument.

   Correction Factor = NIST thermometer value – temperature sensor value

5. Record the date the temperature sensor check was performed and the correction factor that was determined, if applicable, on the field instrument calibration log or in the field book.

2.2 Dissolved Oxygen

DO is the volume of oxygen that is dissolved in water and is typically measured using an electrochemical membrane sensor.

CAUTIONS AND POTENTIAL PROBLEMS WITH DO MEASUREMENTS

- The DO probe's membrane and electrolyte solution should be checked prior to the sampling period and replaced if needed. If wrinkles or air bubbles are present under the membrane, if the membrane is torn or dirty, or if the electrolyte solution looks contaminated, replace both the membrane and electrolyte solution prior to calibration. Failure to perform this step may lead to erratic or erroneous measurements.
- Rental instruments are routinely maintained by the vendor, but the membrane should be checked for signs of wear upon receipt.
- If the probe reading shows the error message, "value out of range", the instrument probe must be recalibrated at a minimum. If the error persists, replace the sensor membrane and recalibrate.
- Most meters will allow you to calibrate the meter in air or against a wet sponge, which gives a "saturated air" calibration. Like pH, conductivity, and ORP, DO is heavily dependent on temperature. DO is also dependent upon barometric pressure. Typically DO is calibrated by entering the barometric pressure (usually in mm of mercury).

Barometric pressure is dependent upon elevation, so be aware of substantial differences in elevation between your sampling location and the location from which you are obtaining the barometric pressure reading. Use the Oxygen Solubility at Indicated Pressure chart in Attachment A for comparison to your calibrated reading.

- Barometric pressure should be corrected to local altitude for DO calibration:

  True BP (mm Hg) = [Corrected BP (mm Hg)] – [2.5 * Local Altitude (ft. above sea level)/100]

- If the calibration cup is used for DO, ensure the cup is loose to allow for pressure equilibration.
- Wait 3 to 5 minutes for the air in the cup to saturate with water during DO calibration.
- If calibrating in air, remove water droplets from the membrane by shaking the probe prior to inserting it into the calibration environment.
- Allow the temperature to stabilize completely in the calibration environment.
- Always keep the sensor clean of biofouling, such as bacteria or algae growth which may generate or consume oxygen resulting in erroneous readings.
- Keep the sensor free of oil, which could clog the membrane and prevent oxygen from diffusing to the sensor.
- Store the probe in a moist environment to keep the membrane from drying out, but do not store it in water which could encourage algae growth on the probe.

CALIBRATION PROCEDURE

1. Gently dry the temperature sensor according to manufacturer's instructions.

2. Place a wet sponge, a wet paper towel, or 1/8 inch of water on the bottom of the DO calibration container that comes with the instrument. (The protective cover of the probe assembly also serves as the container used for the DO calibration.)

3. Place the DO probe in the container without the probe coming in contact with the wet sponge or paper towel. The probe must fit loosely in the container to ensure it is vented to the atmosphere.

4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 3 to 5 minutes as temperature becomes stable). During this time, turn on the instrument to allow the DO probe to warm up (may require at least 10-20 minutes warm-up time).

5. Record the barometric pressure (usually in mm of mercury) from the instrument's onboard sensor, if available. If the instrument does not have an onboard barometer, this measurement can also be determined from an on-site barometer if a weather station is on site and manually entered into the meter. It is recommended that the barometric pressure not be obtained from the local weather service unless the pressure is corrected for the elevation of the sampling location and this is the only source of barometric data. [**Note:** inches of mercury times 25.4 mm/inch mercury equals mm of mercury].

6. Record the DO reading in mg/L and percent and compare this reading to the Oxygen Solubility at Indicated Pressure chart in Attachment A. For example, if the barometric pressure is 750 mm Hg and the temperature inside the calibration cup is 25°C, the DO in mg/L reading should be 8.13 mg/L. Record this value on the field instrument calibration log.

7. If the values recorded on the field instrument calibration log for DO in mg/L do not agree with the published values from Attachment A and are not within the accuracy of the instrument (such as ± 0.2 mg/L and ± 2%, depending on the reading), repeat calibration. If this does not work, change the membrane and electrolyte solution and repeat calibration.

8. Remove the probe from the container, rinse it with deionized water, pat it dry with a towel, and place it into a zero (0.0 mg/L) DO standard if being used as part of the calibration. Fill the protective cup with the fresh zero DO standard. Pour the zero DO standard into the protective cup; the standard should be close enough to the top, so that the DO probe fits tightly into the container (no headspace). Check and record the unit's temperature reading.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read between -0.5 and +0.5 mg/L or to the accuracy of the instrument (usually ± 0.2 mg/L) within 3 minutes. Record this value on the field instrument calibration log. If the instrument does not reach this value, it may be necessary to clean the probe and change the membrane and electrolyte solution. Repeat the zero DO step if the value obtained is not acceptable. If this does not work, prepare a new 0.0 mg/L standard. If these procedures do not work, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: For Zero DO checks: The solution used for this check contains sodium meta-bisulfite or sodium sulfite, which are harmful to the sensor and membrane. It is common practice to recalibrate the meter to 100% saturation after conducting a zero DO check to confirm that the sensor is still operating correctly. A zero DO check is not performed every day the instrument is in use for this reason, but a check should be performed at a minimum of once per sampling event. If conducting this check, be sure to record the manufacturer, true value, lot number, and expiration date of the solution on the field instrument calibration log.

2.3 pH

The pH is the measure of the degree of the acidity or alkalinity of a solution as measured on a scale of 0 to 14 SU. The pH of a sample is determined electrometrically using a glass electrode. All pH measurements are in SU.

CAUTIONS AND POTENTIAL PROBLEMS WITH PH MEASUREMENTS

- Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. For ground water, the pH will usually be close to 7 SU. A minimum of two standards are typically needed for the calibration: one close to 7 SU, one at least two pH units below 7 SU or at least two pH units above 7 SU. The instrument will need to be re-calibrated if the water sample's pH is outside the range defined by the two standards used in the initial calibration, either by adding a third calibration point (if the meter will allow) or by selecting two new pH standards that bracket the water sample's pH.

- Regardless if performing a two- or three-point calibration, always calibrate with pH 7 buffer first.

CALIBRATION PROCEDURE

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards to ensure the pH probe and temperature sensor are completely submerged.

3. Remove the cover of the probe, rinse the probe in a cup filled with deionized water or use a spray bottle, and blot the probe dry with a soft tissue.

4. Enter the value of the first pH buffer solution (e.g., pH 7), immerse the probe in the standard, and allow at least 1 minute for temperature equilibration before proceeding. Record the temperature on the field instrument calibration log.

5. Enter the buffered solution value (7) into the pH calibration menu of the instrument. Allow the pH reading to stabilize for approximately 30 seconds, and if the reading does not change, finish the calibration and record the calibrated value on the field instrument calibration log. The calibration values after adjustment shall be within the accuracy of the instrument, or as required by the project. For example, if the accuracy of the meter is $\pm$0.1 SU, then the calibration values after adjustment shall be between 6.9 and 7.1 SU. If the calibration values after adjustment are outside of this range, recalibrate. If readings continue to fluctuate or readings do not stabilize after recalibration, consult the equipment vendor for troubleshooting or equipment replacement (e.g., may need a new pH electrode).

6. Remove probe from the initial buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

7. Immerse probe into the second buffer solution (e.g., pH 4). Repeat step #5, substituting “4” into the pH calibration menu instead of “7”.

8. Remove probe from the second buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

9. Immerse probe in third buffer solution (e.g., pH 10) or continue to step #11 if only a two-point calibration is being performed. Repeat step #5, substituting “10” into the pH calibration menu instead of “7”.

10. Remove probe from the third buffer solution, rinse in a cup filled with deionized water or use a spray bottle, and blot dry with soft tissue. Dispose of the used buffer solution.

11. To perform the instrument pH check, select monitoring/run mode, (ensure that the initial buffer solution temperature [pH 7] has not changed), and immerse the probe into the buffer solution. Wait for the reading to stabilize. The instrument should read the initial standard value (7 SU) within the accuracy of the instrument, or as required by the project. Record the pH 7 check reading on the field instrument calibration log. If the reading is not within the acceptance criteria, then re-calibrate the instrument. If re-calibration does not correct the

instrument reading, then the calibration range may be too wide. Reducing the calibration range by using standards that are closer together may improve the instrument's accuracy.

2.4 Specific Conductance

Conductivity is used to measure the ability of an aqueous solution to conduct an electrical current. Specific conductance is the conductivity value corrected to 25ºC. Calibrating an instrument for specific conductance automatically calibrates the instrument for conductivity and vice-versa.

CAUTIONS AND POTENTIAL PROBLEMS WITH SPECIFIC CONDUCTANCE MEASUREMENTS

- Most instruments are calibrated against a single standard that is near the specific conductance of the environmental samples. A second standard that is above the environmental sample specific conductance can be used to check the linearity of the instrument in the range of measurements. However, a single-point calibration standard is adequate to assess the accuracy and operation of the sensor.
- Calibrate the conductivity with a standard near the anticipated conductivity of the water. For fresh water, a 1 mS/cm standard is appropriate.
- For some meters, it is important that the top vent hole of the conductivity sensor be immersed during the calibration. Review the instrument manual to determine if this is required.
- Specific conductance/conductivity can have different units (e.g., mmho/cm, mS/cm, µmho/cm, µS/cm), especially on auto-ranging instruments. Note: mhos/cm = Siemens/cm. Check with the Project Manager or database manager to determine if field measurements should be restricted to a consistent unit (e.g., µmhos/cm or µS/cm, not mmhos/cm or mS/cm) so that conversion is not necessary when importing data into a database.
- Be aware of meters which autocorrect for temperature and how to enter the calibration value per the procedures in the instrument's manual. To calibrate instruments that autocorrect for temperature, enter the calibration value of the solution (µmhos/cm at 25°C). For instruments without automatic temperature compensation, the solution's conductivity value must be corrected for the temperature that the sensor is reading before entering the value into the meter. In some cases, you may be able to adjust the temperature of the calibration solution to near 25°C, such that the standard calibration value is applicable; otherwise an adjustment for temperature needs to be accounted for. Additionally, if calibrating for conductivity instead of specific conductance, the solution's conductivity value must be corrected for the temperature that the sensor is reading.

CALIBRATION PROCEDURE

1. Allow the calibration standard to equilibrate to the ambient temperature.

2. Remove probe from its storage container, rinse the probe with a small amount of deionized water, and pat dry the sensor with a soft tissue.

3. Lower the sensor into the conductivity standard. Gently move the probe up and down in the solution to remove any air bubbles from the sensor if present. Allow the probe to sit in the solution for at least 30 seconds to allow values to equilibrate before proceeding.

4. Enter the calibration value of the solution (e.g., 1,413 µmhos/cm at 25°C). Record the temperature of the solution on the field instrument calibration log, and allow the specific conductance reading to stabilize for approximately 30 seconds. Record the calibrated value after stabilization on the field instrument calibration log. The reading should be within ±5% of the true value. If the reading is not within this range, recalibrate. If readings continue to fluctuate significantly after a recalibration, consult the equipment vendor for troubleshooting or equipment replacement.

5. Remove probe from the standard, rinse the probe with deionized water, and replace the protective cover over the sensors.

2.5 Oxidation-Reduction Potential (ORP)

The oxidation-reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

CAUTIONS AND POTENTIAL PROBLEMS WITH ORP MEASUREMENTS

- Note that ORP is not usually the same as Eh. Eh is ORP measured relative to a standard hydrogen electrode (SHE). Typical ORP reference electrodes used in the field are Ag/AgCl electrodes, not SHEs. The difference is that Eh would be approximately 200mV higher than ORP measured against a Ag/AgCl reference electrode. See Standard Methods 2580B and YSI Tech Note (2005) for more details.
- Some meters allow you to calibrate ORP, but many do not allow calibration. Testing solutions are available to verify your ORP reading but they are not accurate enough to be used as calibration standards.
- ORP is temperature dependent. Look up the millivolt (mV) calibration value at the measured temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures.

CALIBRATION OR VERIFICATION PROCEDURE

1. Allow the calibration standard (e.g., a Zobell solution) to equilibrate to ambient temperature.

2. Remove the cover of the probe, and place it into the standard.

3. While stirring the standard, wait for the probe temperature to stabilize, and then read the temperature.

4. Look up the millivolt (mV) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. It may be necessary to interpolate millivolt values between temperatures. Enter the

temperature-corrected ORP value, and calibrate the instrument. Record the values on the field instrument calibration log.

5. The reading should remain unchanged within manufacturer's specifications. If it changes, re-calibrate. If readings continue to change after calibration, consult the manufacturer.

6. If the instrument instruction manual states the instrument is factory calibrated, then verify the factory calibration against the standard. If the reading does not agree with the standard within the accuracy of the instrument, the instrument will need to be re-calibrated by the manufacturer.

2.6 Turbidity

Turbidity refers to how clear the water is and is a measure of relative sample clarity. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidity meter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed 90 degrees to the path of the light source. Turbidity values are recorded in NTUs.

CAUTIONS AND POTENTIAL PROBLEMS WITH TURBIDITY MEASUREMENTS

- Some instruments will only accept one standard. For these instruments, the standards will serve as check points.
- Some regulatory agencies will not allow turbidity measurements through a flow-through cell, and require a stand alone turbidity meter. Verify that the selected meter will meet project objectives prior to use.
- For the greatest accuracy during the calibration procedure, ensure that after the meter is blanked and the blank is scanned as a sample, the reading is 0.00 NTU. If not, re-zero the meter and scan the blank again until it reads 0.00 NTU. When scanning the calibration standards as the sample, scan the calibration standard three times removing the tube from the chamber after each scan. The readings should be consistent. Use the last consistent reading to calibrate the meter. If the readings are not consistent, avoid using an aberrant reading to calibrate the meter.
- The meter should be placed on a surface that is free from vibrations. Vibrations can cause high readings.
- Gently mix the sample by inverting before taking a reading, but avoid introducing air bubbles.
- Scratches, fingerprints, and water droplets on the outside of the cuvettes can cause additional light scatter, leading to inaccurate readings. If necessary, wipe the outside of the cuvette with a soft tissue. If the cuvette is scratched or dirty, discard.
- Ensure that the cuvette is always placed in the chamber in the same orientation, as differences in orientation can cause differences in results. Proper cuvette orientation may be indicated by a mark or arrow on both the cuvette and the instrument.

CALIBRATION PROCEDURES – STAND ALONE TURBIDITY METER

NOTE: Sometimes standards are provided in the cuvette with the meter.

1. Rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe the inside of the cuvette, because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

2. Place the 0.0 NTU standard into the instrument and scan the sample (measure the standard). Record the reading on the field instrument calibration log. The 10.0 NTU standard can be measured after the 0.0 NTU standard is scanned.

3. Select the 10.0 NTU standard and scan the sample (measure the standard). The reading should be within $\pm$10% of the true value. Record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, then move on to step # 5. If not, calibrate the instrument to 10.0 NTU. Record the reading and any significant changes on the field instrument calibration log.

4. After adjusting the calibration, re-read the 10.0 NTU standard to ensure it is now meeting accuracy requirements. If not, repeat step #3. Otherwise, continue to step #5.

5. Repeat step #3, if needed, for the 1.0 NTU standard.

6. After adjusting the calibration, re-read the 1.0 NTU standard to ensure it is now meeting accuracy requirements ($\pm$10% of the true value). If not, repeat step #3. Otherwise, continue to step #7.

7. As a final check of the instrument, scan the blank (0.0 NTU standard). The unit display should read very close to zero. Record the reading on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is >50% from the expected value (e.g., 0.49 NTU for the 1.0 NTU standard), scrolling to the true value (e.g., 1.0 NTU) and attempting to calibrate will result in an error code, because the value to which you have changed it is >50% of the expected value of the standard. In this case, it is necessary to re-calibrate the unit from the beginning starting with a blank. If this fails to produce adjustable and reproducible values for the 1.0 and 10.0 NTU standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

   NOTE: If only performing a two-point calibration (depending on project requirements), the 0.0 NTU and 10 NTU (or comparable NTU level) standards should be used.

CALIBRATION PROCEDURES – MULTI-PARAMETER METER WITH FLOW-THROUGH CELL

This is a two point calibration with a standard and turbidity free water. The standard can be formazin, polymer beads, or a meter-specific quick calibration solution. Turbidity free water can be obtained by filtering distilled or deionized water through a 0.1, 0.3, or 0.45 micron filter.

1. Rinse the calibration cup and sensors with the turbidity free water. Fill the cup with enough water so that the turbidity sensor is covered (sensors pointed down).

2. Scan the sample (measure the standard). After the reading has stabilized, enter the zero turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log.

3. Rinse the calibration cup and sensors with the standard solution. Fill the cup with enough standard solution so that the turbidity sensor is covered (sensors pointed down).

4. Scan the sample (measure the standard). After the reading has stabilized, enter the standard solution turbidity value into the meter in accordance with manufacturer directions and record the reading on the field instrument calibration log. If the reading is within the acceptance criteria, calibration is complete. If not, recalibrate the instrument. Record the reading and any significant changes on the field instrument calibration log.

   NOTE: If during the calibration procedure, you find the value of the standard is outside of the range acceptable by the meter and attempting to calibrate results in an error code, it is necessary to re-calibrate the unit from the beginning starting with a blank/turbidity free water. If this fails to produce acceptable and reproducible values for the standards, re-calibrate using new standards and discard the current standards. If the meter still fails to calibrate following repeated attempts at calibration, consult the equipment vendor for troubleshooting or equipment replacement.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum or roll-off bin, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

In addition to checking the calibration of instruments prior to measurements, calibration checks may also be required at other times of the day. If there are significant temperature fluctuations or erroneous readings, a calibration check may be required. Some programs require a post-calibration check at the conclusion of the day to ensure that instrument drift has not occurred. Refer to the site-specific work plan for calibration frequency.

Comparing current values with historical values at the same measuring location can be helpful in assessing instrument and calibration reliability.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All work must be dated and signed by the analyst. Any changes should be crossed out with a single line, initialed, and dated.

Prior to calibrating, the field equipment and calibration standard information should be recorded on a field instrument calibration log and/or in the field book. For field equipment, the information recorded should include the make, model number, and the serial number of the instrument. Each instrument can be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log.

For calibration standards, the information recorded should include the manufacturer, expiration date, true value, and any other description, such as lot number. Each calibration standard can also be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log. If standards are not supplied with an expiration date, the standards should be initialed and dated when received and when opened (not applicable for standards supplied with the rental equipment).

The calibration records provided by the equipment vendor and the certificates of analysis for each standard will be maintained in the project files.

All calibration measurements must be documented in the field book or on a separate field instrument calibration log. Example field instrument calibration logs are presented in Attachment B. At a minimum, the field instrument calibration log must include the instrument information described above, calibration standard information described above, calibration date, and the instrument calibration results.

6.0 REFERENCES

USEPA. January 19, 2010. *Standard Operating Procedure, Calibration of Field Instruments,* Revision No. 2. USEPA Region I.

American Public Health Association, American Water Works Association, and Water Environment Federation. January 2012. *Standard Methods for the Examination of Water and Wastewater,* 22nd Edition.

YSI Environmental. 2005. *Measuring ORP on YSI 6-Series Sondes: Tips, Cautions and Limitations*. YSI Environmental Tech Note. http://www.ysi.com/media/pdfs/T608-Measuring-ORP-on-YSI-6-Series-Sondes-Tips-Cautions-and-Limitations.pdf.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	NOVEMBER 2014	NOT APPLICABLE

Attachment A

Oxygen Solubility at Indicated Pressure

Attachment A (page 1 of 2)

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment A (Page 2 of 2)

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Table taken from EPA Region I SOP, Calibration of Field Instruments, January 10, 2010.

Attachment B

Example Field Instrument Calibration Logs

TRC Field Instrument Calibration Log

Date:______________________ Site Name:______________________

Water Quality Instrument Type / ID:____

Turbidity Instrument Type / ID:____

Date of Last Temperature Probe Check:____________

Dissolved Oxygen (DO)

Time	Barometric Pressure (mm Hg)	Temperature (°Celsius)	Oxygen Solubility at Indicated Pressure (mg/L) (On Instrument)	Actual Oxygen Solubility at Indicated Pressure (mg/L) (Refer to Attachment A)	Zero DO Check (mg/L)	Comments	Initials

pH

Time	Solution Temperature (°Celsius)	pH 7	pH 4	pH 10	pH 7 Check	Comments	Initials

Specific Conductance

Time	Specific Conductance Reading (umhos/cm3)	Comments	Initials

Oxidation Reduction Potential (ORP)

Time	Solution Temperature (°Celsius)	ORP Reading (mV) (Refer to std instruction sheet)	Actual ORP Reading (mV) (On instrument)	Comments	Initials

Turbidity

Time	Zero Standard	Standard #1 (___NTUs)	Standard #2 (___NTUs)	Comments	Initials

Calibration Fluid ID / Expiration Date:

Zero DO:______________ Specific Conductance:______________

pH 4:______________ pH 7:______________ pH 10:______________

ORP:______________

Zero Turbidity:________________ Turbidity Std. # 1:______________ Turbidity Std. # 2:______________

Signed___________________________________

PAGE ______ OF ______

WATER QUALITY METER CALIBRATION LOG

PROJECT NAME: 0	MODEL:	SAMPLER: SN
PROJECT NO.: 0.00	SERIAL #:	DATE:

PH CALIBRATION CHECK

pH 7 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	pH 4 / 10 (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	CAL. RANGE	TIME
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

SPECIFIC CONDUCTIVITY CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

ORP CALIBRATION CHECK

CAL. READING (LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

D.O. CALIBRATION CHECK

CAL. READING POST-CAL. READING /SATURATED AIR	TEMPERATURE (°CELSIUS)	CAL. RANGE	TIME
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	
/		☐ WITHIN RANGE	

TURBIDITY CALIBRATION CHECK

CALIBRATION READING (NTU)		CAL. RANGE	TIME
(LOT #): (EXP. DATE): POST-CAL. READING / STANDARD	(LOT #): (EXP. DATE): POST-CAL. READING / STANDARD		
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	
/	/	☐ WITHIN RANGE	

COMMENTS

☐ AUTOCAL SOLUTION	☐ STANDARD SOLUTION (S)
(LOT #): (EXP. DATE):	LIST LOT NUMBERS AND EXPIRATION DATES UNDER CALIBRATION CHECK
CALIBRATED PARAMETERS	**CALIBRATION RANGES (1)**
☐ pH	pH: +/- 0.2 S.U.
☐ COND	COND: +/- 1% OF CAL. STANDARD
☐ ORP	ORP: +/- 25 mV
☐ D.O.	D.O.: VARIES
☐ TURB	TURB: +/- 5% OF CAL. STANDARD
☐ ____________	(1) CALIBRATION RANGES ARE SPECIFIC TO THE MODEL OF THE WATER QUALITY METER
☐ ____________	

NOTES

PROBLEMS ENCOUNTERED	CORRECTIVE ACTIONS

SIGNED ______________________ DATE ______

CHECKED BY ______________________ DATE ______

REVISED 06/2011

Attachment C

SOP Fact Sheet

WATER QUALITY PARAMETER INSTRUMENT CALIBRATION

PURPOSE AND OBJECTIVE

Before a meter is utilized in the field, it will be calibrated and checked in accordance with this SOP to ensure proper operation. Water quality instruments addressed in this SOP include those that measure temperature, pH, dissolved oxygen (DO), conductivity/specific conductance, oxidation-reduction potential (ORP), and turbidity for the purposes of field screening and field measurements.

WHAT TO BRING

- Appropriate Level of PPE
- Field book
- Field instrument calibration logs
- Water quality meter capable of measuring one or more of the following based on project scope: pH, temperature, DO, specific conductivity, and ORP (e.g., YSI 600XL, Horiba U-50, Hydrolab Quanta/QED MP-20, or equivalent)
- Deionized water
- Flow-through cell
- Ring stand with clamp
- Paper towels
- Soft tissue (e.g., Kimwipes®)
- Cuvettes
- Buffer solutions at pH 4, 7 and 10 standard units (SU)*
- Conductivity solution (potassium chloride, typically 1,413 μhos/cm)*
- ORP calibration solution (e.g., Zobell)*
- Turbidity standards (0, 1, 10 nephelometric turbidity units [NTUs] or StablCal Kit)*
- Zero DO solution (0.0 mg/L)*
- DO membrane kit (electrolyte solution, membranes)
- NIST thermometer (0.2°C accuracy)*
- Small glass or polyethylene jars to hold the calibration standards (4-8 oz.)
- Cup or spray bottle for the deionized water

*Dependent on the project-specific requirements and the instrument manufacturer

OFFICE

- Review project work plan and confirm what field measurements are required based on the scope of work.
- Confirm that all necessary equipment (including necessary calibration solutions) are available in-house or order if necessary.
- All meters may have different relative accuracy, which will be specified in the instrument manual. Confirm that the meter being used meets the project's accuracy requirements.
- Confirm that a copy of the manufacturer's instruction manual is available to accompany the instrument into the field.
- Properly clean/decontaminate the instrument before storage or returning equipment to rental vendor.

CALIBRATION PROCEDURES

- Prior to use, inspect instruments to ensure instruments are clean, check for possible malfunctions, and calibrate in accordance with manufacturer's procedures. Note: The initial calibration may be performed in the office prior to the field event or by the equipment supplier; however, calibration checks should be performed on site prior to use on the day of the fieldwork.
- Calibration checks (or verifying that instrument readings fall within an acceptable range of a standard without running through the full instrument calibration steps) will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of faulty readings or instrument malfunction occurs. Some instruments or certain project scopes may require more frequent calibration checks depending on project quality objectives.
- In general, instrument selection and calibration will include the following steps:
  1. Determine which instruments are needed for the specific field tasks. Record the make, model number, and serial number of the instrument on the field instrument calibration log or in the field book.
  2. Obtain the necessary instruments and standard solutions for calibration. Check expiration dates on standard solutions and replace if out of date. Record the manufacturer, true value, lot number and expiration date of the standard solutions on the field instrument calibration log or in the field book.
  3. Assemble the instrument and turn it on allowing the instrument to warm up.
  4. Check battery charge, and charge or replace if necessary.
  5. Clean instrument (if necessary).
  6. If applicable, program the multi-probe instrument so that the applicable parameters to be measured will be displayed.
  7. Calibrate the instrument prior to field use in accordance with manufacturer's procedures. (Note: If applicable, calibrate DO and conductivity first, because these parameters may affect the other calibrations).
  8. Document all calibration activities and results in the field instrument calibration log or field book.
  9. If the instrument malfunctions and cannot be corrected, document the issues, qualify any erroneous data, and obtain a replacement.
  10. Clean and decontaminate the instrument after use and before storage.

11. Conduct calibration checks at least once per day or additionally as needed.

INVESTIGATION-DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

- Prior to calibrating, the field equipment and calibration standard information should be recorded on a field instrument calibration log and/or in a field book. For field equipment, the information recorded should include the make, model number, and the serial number of the instrument. Each instrument can be assigned an identification number that can be referenced in future field notes or when filling out the field instrument calibration log.
- For calibration standards, the information recorded should include the manufacturer, expiration date, true value, and any other description, such as lot number.
- The calibration records provided by the equipment vendor and the certificates of analysis for each standard will be maintained in the project files.
- All calibration measurements must be documented in a field logbook or on a separate field instrument calibration log. At a minimum, the field instrument calibration log must include the instrument information described above, calibration standard information described above, calibration date, and the instrument calibration results.

DOs AND DO NOTs OF WATER QUALITY PARAMETER INSTRUMENT CALIBRATION

DOs

- DO wear appropriate PPE (i.e., chemical resistant gloves and safety glasses) when cleaning and calibrating water quality instruments.
- DO confirm what field measurements are required, and what accuracy is required based on the scope of work.
- DO ensure you have the instrument instruction manual available if needed, as well as contact information for the manufacturer or rental company for troubleshooting questions.
- DO properly document calibration procedures and calibration checks performed.
- DO note when erroneous readings/equipment malfunctions are observed and any troubleshooting and/or corrective measures taken.
- DO conduct calibration checks at least once per day or additionally as needed.
- DO properly store the calibration standard solutions. Avoid extreme hot/cold temperatures. Frozen solution is useless and extreme temperatures can make calibration difficult and/or calibration may not work at all.

DO NOTs

- DO NOT use expired calibration solutions.
- DO NOT immerse the sensors in sea water or other highly saline water, alcohol, or organic solvents.
- DO NOT forget to clean and decontaminate the instrument after use and before storage.
- DO NOT store the sensors improperly (e.g., avoid storing in extreme hot or cold temperatures, make sure appropriate storage solutions are being used per manufacturer's recommendations).

Title: **Soil Sampling**	Procedure Number: **ECR 003**
	Revision Number: **01**
	Effective Date: **November 2016**

Authorization Signatures			
Darby Litz		Elizabeth Denly	
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Darby Litz	11/14/16	Elizabeth Denly	11/14/16

TABLE OF CONTENTS

LIST OF ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the logistics, collection techniques, and documentation requirements for collecting representative soil samples. These are standard (i.e., typically applicable) operating procedures that may be changed, as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In addition, other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Portions of this SOP may be applicable to soil sample collection for geotechnical analysis. However, specific instructions for collection of geotechnical samples are not provided; these samples should be collected in accordance with ASTM methods or other applicable standards.

1.2 Summary of Method

The objective of soil sampling is to obtain a representative sample of soil for laboratory analysis of constituents of interest at a given site. This objective requires that the sample be of sufficient quantity and quality for analysis by the selected analytical method. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details. Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near-surface soils may be sampled using a spade, trowel, and/or scoop. Sampling at greater depths typically is performed using a hand auger, continuous flight auger, a split-spoon, direct-push methods (i.e., Geoprobe®), sonic drilling, a backhoe or an excavator. The following reference may be used as a guide to aid in selecting an appropriate method or sampling device for the collection of subsurface soil samples with a drill rig: ASTM D6169–98 Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigation.

1.3 Equipment

The following equipment may be utilized when collecting soil samples. Project-specific conditions or laboratory requirements may warrant the addition or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP).
- Sample containers (may be supplied by the laboratory, depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project.

  For non-volatile organic compound (VOC) parameters, glass containers with Teflon®-lined caps are typically utilized. Typical containers used for VOC parameters are provided in Attachment A. Brass liners, steel liners, or soil core acetate liners with Teflon® tape and plastic end caps may also be used.

- En-Core® samplers.
- Disposable plastic syringes or Terra Core™ samplers.
- Stainless steel mixing bowl.
- Stainless steel spoon or spatula.
- Hand auger, mud auger, sand auger, bucket auger and T-handle.
- Post hole auger.
- Extension rods.
- Stainless steel trowel.
- Shovel.
- Tape measure, folding ruler.
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags.
- Field book and/or boring log.
- Sample container labels.
- Chain-of-custody (COC) forms (TRC or laboratory, as appropriate).
- Camera.
- Maps/site plan.
- Survey equipment and/or global positioning system (GPS) and/or other means of measuring sample locations.
- Indelible marking pens or markers.
- Organic absorbent (e.g., Slickwick, ground corn cob, sawdust).
- Sample coolers.
- Bubble wrap.
- Ice (for sample storage/preservation).
- Zip-loc® plastic bags (for ice and COCs).
- Equipment decontamination supplies.

1.4 Definitions

Composite sample	Composed of a number of grab samples collected over a period of time or space during a single sampling event and mixed together.
En-Core® sampler	A disposable volumetric sampling device with an airtight sealing cap.
Grab sample	Individual discrete sample collected at a particular time.

High-level VOC analysis	VOC soil analysis that yields high reporting limits (approximately 50-200 µg/kg, depending on the laboratory). Samples are typically preserved in methanol and cooled to 4°C. High-level VOC analyses are used for samples that are expected to contain elevated concentrations of VOCs (>200 µg/kg).
Low-level VOC analysis	VOC soil analysis that yields low reporting limits (approximately 5 µg/kg, depending on the laboratory). Samples are typically preserved in water, cooled to 4°C, and frozen within 48 hours of collection. Low-level VOC analyses are used for samples that are expected to contain lower concentrations of VOCs (≤200 µg/kg).
Terra Core™ sampler	A disposable volumetric sampling device used to transfer soil samples to the appropriate sample containers.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE, as defined in the HASP.

Soil samples containing chemical contaminants may be handled during implementation of this SOP. Additionally, sample preservatives including caustics and/or acids may be considered hazardous materials and TRC employees will appropriately handle and store them at all times Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Hazardous substances may be incompatible with clothing or equipment; some substances can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through inhalation or skin contact or if exposed to heat/flame and they combust. Material safety data sheets for chemicals handled by TRC should be maintained in the field.

1.6 Cautions and Potential Problems

- Cross contamination: Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary.

- Improper sample collection: Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

- Special considerations for the different soil sampling techniques are provided below in the applicable sections. Cautions and potential problems associated with soil sampling for VOCs are provided in Attachment A.

- Special care should be taken when sampling for PFAS. Please refer to Attachment D for details.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Always review the site-specific work plan and/or scope of work for any site-specific sampling procedures.

2.1 Pre-Sampling Activities

Pre-sampling activities that the sampling team should consider include the following: preparing a sampling strategy; reviewing the work plan approved by the regulatory agency; selecting a laboratory, and determining laboratory-specific procedures related to bottle orders, holding times, work orders, methods of analysis, COC procedures, data deliverables, schedule, and cost. Additional activities include determining shipping logistics, utility clearance, and handling of investigation-derived waste disposal. Pre-labeling bottles can help to reduce sampling and labeling errors.

The following steps should also be employed.

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or clean equipment, and ensure that it is in working order.

4. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific HASP.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.
   NOTE: If spray paint is used to mark stakes, the spray paint should be carefully isolated from the space used to hold sample bottles, sampling equipment, etc.

7. Prior to any subsurface soil sampling, especially that completed with a drill rig or backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities by conducting a utility survey/markout.

2.2 General Soil Sampling Procedures

1. Refer to other TRC SOPs for the proper procedures for classifying soil samples and for screening of samples for VOCs. Special care is required when sampling for PFAS. Please refer to Attachment D for details.

2. **For sampling in the State of California only:** When the sampling interval is predetermined and soil samples are collected by direct-push methods into an acetate liner, the section of the liner corresponding to the predetermined depth interval may be cut off and submitted to the laboratory for analysis with the exception of samples for VOC, volatile petroleum hydrocarbon (VPH), or gasoline-range organics (GRO) analysis. If VOC, VPH, or GRO analysis is required, then these samples can be collected from either open end of the acetate liner section according to the procedures outlined in Attachment A prior to packaging and submitting it to the laboratory. The laboratory should be consulted for the required length of liner tube (i.e., sample volume) depending on the analytical suite and to ensure that the use of acetate liners is appropriate for the analytical method(s). After collecting material for the VOC, VPH, or GRO analysis samples (if required), seal each end of the acetate liner section with Teflon tape and plastic end caps. Wrap the ends with non-volatile tape and label the acetate liner with the sample identification (ID) and date and time of collection. Ensure that the laboratory will perform homogenization of the soil sample within the acetate liner and proceed to Step #9.

3. Prior to the collection of soil samples from a particular location or depth, the soil is typically screened for organic vapors with a portable meter equipped with a flame ionization detector (FID) and/or photoionization detector (PID) depending upon the suspected contaminants of concern and site-specific work plan requirements. Such organic vapor screening may be used to determine appropriate soil sample locations or depths for laboratory VOC analysis depending upon established site-specific work plan requirements. Soil should be screened *in situ* or immediately upon retrieval of the soil sample from the subsurface.

4. Samples for VOC, VPH or GRO analysis are then collected as soon as possible after the soil has been exposed to the atmosphere and prior to sample collection for other analyses.

    - **These samples are NOT homogenized.**
    - These samples are generally collected using an open-barrel disposable syringe, a Terra Core™ sampler, or an En-Core® sampler, or equivalent. Note that En-Core® samplers are not recommended for non-cohesive soils (see Attachment A).
    - Refer to the site-specific work plan or governing regulatory authority for preservation requirements for VOC, VPH or GRO analysis. Attachment A of this SOP includes typical procedures on the collection and preservation of soil samples for VOC, VPH and GRO analysis.

5. After collecting the sample for VOC analysis, the sample portion for the remaining analysis should be well homogenized, *in situ* (if possible, such as with surface soil sampling), or in a decontaminated stainless steel bowl or disposable new aluminum pie pan. These soil samples

must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. Soil can be homogenized and transferred to sample containers using soil sampling devices that have been decontaminated prior to use or individually wrapped, sterile, new polystyrene devices. Such sterile, polystyrene devices are generally for one-time use. Stainless steel devices may be decontaminated and individually foil wrapped, plastic bagged, or field decontaminated and foil wrapped between uses. Decontamination of sampling equipment shall be conducted in accordance with TRC's SOP on equipment decontamination.

6. Stones, gravel, or vegetation should be removed from the soil sample as much as practical prior to placement in sample containers, since these materials will not be analyzed. Visible asphalt, concrete, ash, slag, and coal debris should also be removed from the sample as much as possible to ensure sufficient soil quantity for laboratory analyses, unless these matrices are part of the overall characterization program. The soil sample must be representative of what the end user is trying to characterize. In addition, if such debris is to be tested, further sample preparation (e.g., pulverizing) will likely be necessary in the field or laboratory. In any case, the presence of any such materials in the soil at the sample location must be documented in the field book.

7. Filling of the sample bottles should be completed immediately after sample collection to minimize losses due to volatilization and biodegradation. Soil classification can be completed following sample collection.

8. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

9. Restore the sampling location to grade in accordance with applicable state or federal guidelines and/or the site-specific work plan. Options include backfilling the sample location with the remaining removed soil, bentonite pellets or, cement/bentonite grout depending on site conditions and patching the surface to match the surrounding area (e.g., topsoil with grass seed, asphalt or concrete patch), as necessary. Boreholes must be abandoned or backfilled after the completion of sampling. In general, shallow boreholes (e.g., less than 10 feet deep) that remain open and do not approach the water table may be abandoned by pouring a cement/bentonite grout mixture from the surface or pouring bentonite pellets from the surface and hydrating the pellets in lifts. The grout mixture should be based on site-specific conditions (e.g., boring depth, groundwater depth, and formation permeability), site-specific work plan procedures, and local regulatory requirements. Boreholes where bridging of the bentonite may be an issue, such as boreholes that intercept groundwater or are greater than approximately 10 feet in depth, should be backfilled by pressure grouting with a cement/bentonite grout mixture, either through a re-entry tool string or through a tremie pipe introduced to within several feet of the borehole bottom.

10. Record locations of soil borings/samples in the field book by sketching a map and/or providing a description of the location. Always measure and record distances to fixed landmarks, such as buildings, fences, curbs, existing surveyed wells, etc. Additionally, a GPS unit with real-time sub-meter accuracy (not applicable for interior samples or other site conditions such as heavy tree/brush cover and thick cloud cover that limit unit connection

with satellites) could be used to document sample locations. Note observations about elevation changes between sample locations.

2.2.1 Surface Soil Sampling Methods

The depth of surface soil samples will be determined on a site-specific basis and may be influenced by site-specific conditions and/or applicable local, state, or federal regulatory programs and potential exposure pathways. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface (bgs). The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes.

The following procedure should be used for surface soil sampling:

1. If a thick, matted root zone, leaf layer, gravel, surface debris, concrete, etc. is present at or near the surface, it should be carefully removed using clean decontaminated tools or clean nitrile gloves before the soil sample is collected. The presence and thickness of any such material should be recorded in the field book for each location. The depth measurement for the soil sample begins at the top of the soil horizon, immediately following any such removed materials.

2. A decontaminated stainless steel spoon, scoop or trowel is typically used for surface soil sampling depths from 0 to 12 inches bgs where conditions are generally soft, and there is no problematic vegetative layer to penetrate. A hand auger or shovel may also be used to dig down to the desired depth and then after careful removal of the dug soils from the hole, a decontaminated stainless steel spoon, scoop or trowel is used to collect the soil sample from the bottom of the hole for laboratory chemical analysis. Plated trowels typically available from garden supply centers should not be used due to potential heavy metal impacts from the trowel plating.

3. When using stainless steel spoons or trowels, consideration must be given to the procedure used to collect a soil sample for VOC analysis. Samples for VOC, VPH or GRO analysis must be collected first and never homogenized or composited. These samples are collected using an open-barrel disposable syringe, a Terra Core™ sampler, or an En-Core® sampler, or equivalent. If the soil being sampled is cohesive and holds its *in situ* texture in the spoon or trowel, the En-Core® sampler or disposable syringe used to collect the sub-sample should be plugged directly from the spoon or trowel. However, if the soil is not cohesive and crumbles when removed from the ground surface for sampling, the sub-sample should be plugged directly from the surface of the appropriate sample depth. Additionally, note that En-Core® samplers are not recommended for non-cohesive soils (see Attachment A). Generally, the sample portion for VOC analysis is collected from several inches below grade to minimize volatilization from the *in situ* soil.

4. Continue by following the General Soil Sampling Procedures in Section 2.2.

2.2.2 Hand Auger Sampling Methods

The shallow subsurface interval may be considered to extend from approximately 12 inches bgs to a site-specific depth at which sample collection using manual collection with a spoon or trowel becomes difficult or impractical. Hand augers may be used to advance boreholes and collect soil samples in shallow subsurface intervals. Often, 4-inch diameter stainless steel auger buckets with cutting heads are used. The auger is advanced by simultaneously pushing and turning using an attached T-handle with extensions (if needed).

Auger holes are advanced one bucket at a time until the appropriate sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and decontaminated or a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and then carefully removed. The practical depth of investigation using a hand auger largely depends upon the soil properties and depth of investigation. In sand, augering is typically easy to perform, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. The use of hand augers may be of limited use in soils containing large amounts of unnatural fill (e.g., brick, slag, concrete), coarse gravel and cobbles (or larger grain size), and in tight clays or cemented sands. In these soil types, it becomes more difficult to recover a sample due to increased friction and torqueing of the hand auger extensions as the depth increases. At some point, these problems become so severe that alternate methods (i.e., power equipment) must be used.

The following procedure is used for collecting soil samples with the hand auger:

1. Attach the auger head to a drill rod extension and attach the T-handle to the rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first several inches of surface soil and any root layer for an area approximately 6 inches in radius around the borehole location.

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the borehole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding rod extensions. It also facilitates refilling the borehole and avoids possible contamination of the surrounding area.

4. When the sample depth is reached, remove the bucket used to advance the borehole and attach a decontaminated or clean bucket. Place the clean auger bucket in the borehole, advance the clean auger bucket to fill it with the soil sample and then carefully remove the clean auger bucket.

5. If VOC analysis is to be performed, collect a sample directly at the bottom of the boring, if within reach, and not from the auger bucket. If not within reach, collect the sample directly from the auger bucket or from minimally disturbed material immediately after the auger bucket is emptied. Use an En-Core® sampler or other coring device (i.e., syringe, Terra Core™) to collect the sub-sample as described in Attachment A. Note: some regulatory agencies do not allow for subsurface VOC sample collection directly with a hand auger; refer to the site-specific work plan and regulatory requirements to ensure the collection of VOC samples with a hand auger is appropriate.

6. Continue by following the General Soil Sampling Procedures in Section 2.2. Note that if another sample is to be collected in the same borehole, but at a greater depth, reattach the auger bucket to the rod assembly, and follow steps 1 through 5 above, making sure to decontaminate the sampling device between samples.

Special Considerations for Hand Auger Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Slough* - Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - If sampling equipment is to be reused at a new sampling location or at a deeper depth in the same location, proper decontamination of sampling equipment is required.

2.2.3 Direct-Push Sampling Methods

Direct-push sampling methods are used primarily to collect shallow and deep subsurface soil samples. Soil sampling probes may range from simple hand tools to truck-mounted or track-mounted hydraulically operated rigs. The basic concept is the same for all of these samplers: the tool is hydraulically driven into the soil, filling the tube, and then the tool is withdrawn. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe two specific sampling methods using direct-push techniques, along with details specific to each method.

- *Macro-Core® Sampler (Direct-push)* **-** The Macro-Core® (MC®) sampler is a solid barrel, direct-push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter (OD) of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration.

- *Dual-tube Soil Sampling System (Direct-push)* - The Dual-tube 21 soil sampling system is a direct-push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of a continuous core inside a cased hole, minimizing or preventing cross contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual-tube assembly and core to its initial sample depth.

The following procedure is used for collecting soil samples from direct-push soil cores:

1. The driller will advance and extract the soil sampler liner which will then be given to the field sampler - confirm with the driller which end is top and which end is bottom. Record the time of core collection (military time), the soil boring ID and the depth interval in feet bgs in the field book.

2. Measurement of vertical depth should start from the top of soil; surface asphalt, surficial concrete slabs, or gravel sub-base should be excluded from the depth measurement unless otherwise specified in the site-specific work plan. However, the presence and thickness of these items should be noted in the field book.

3. Measure the length of recovered soil in inches and record in the field book.

4. Continue by following the General Soil Sampling Procedures in Section 2.2.

   If a specific depth interval is targeted for sampling, be sure to give consideration to the percent recovery of soil when selecting the sample interval. For example, if the targeted sample interval was from 2.0 to 2.5-ft, and the core barrel was advanced from 0 to 4 ft bgs, and 30 inches (2.5 ft) of soil was recovered, the sample should be collected immediately below the mid-point of the recovered soil, or 15- inches below the top of the recovered soil (not including slough). The sample designation will indicate that the depth was 2.0 to 2.5 ft bgs.

<u>Special Considerations for Direct-push Sampling</u>

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Liner Use and Material Selection* - Direct-push soil samples are collected within a dedicated new or decontaminated liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terephthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most investigations, the standard disposable new polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary. However, such costly liner materials typically are not disposable and therefore require decontamination between each use.
- *Sample Orientation* - When the liners and associated sample are removed from the sample tubes, it is important to confirm and maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.
- *Core Catchers* - Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In such cases, the use of core catchers on the

leading end of the sampler may help retain the soil until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core catchers have with the sample material, most standard core catchers available for a tool system will be acceptable.

- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - The cutting shoe and piston rod point are to be decontaminated between each sample. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes, such as with high-pressure water or steam.

2.2.4 Split-spoon Sampling Methods

All split-spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the stub used to attach the spoon to a string of drill rod.

- <u>Standard Split Spoon</u> - A drill rig auger is used to advance a borehole to the target depth. The drill auger string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0- inches OD (1.5-inches inside diameter) and 18- inches to 24- inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition. Split-spoon soil sampling for geotechnical purposes should be conducted in accordance with ASTM Method D1586 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soil*.

The following procedure is used for collecting soil samples from split-spoon soil cores:

1. Record the blow count per 6-inch interval when advancing split-spoon samplers with the hollow stem auger rig. Record the hammer weight (e.g., 140 pounds [lb] is standard, but 300 lb may also be used to advance the spoon). Blow counts are an indication of soil density and are a measure of the number of blows it takes for a 140 lb slide hammer falling over a distance of 30- inches to penetrate 6- inches of soil. The drillers will keep the count and will repeat them to the field sampler (e.g., 11, 13, 16 – means the number of blows the hammer advanced the spoon every 6 inches over a total depth interval of the split-spoon sampler, in this case over 18 inches). If refusal is encountered, the count is recorded in the book as "# of hammer blows / depth in inches the spoon is driven" (e.g., 50/3 – means 50 blows of the hammer advanced the spoon 3 inches).

2. The driller will advance, extract, and open the split spoon, which will then be given to the field sampler - confirm with the driller which end is top and which end is bottom, if a soil sampler liner is used and removed from the spoon. Record the time of core collection (military time), the soil boring ID and the depth interval in feet bgs in the field book.

3. Measurement of vertical depth should start from the top of soil; surface asphalt, surficial concrete slabs or gravel sub-base should be excluded from the depth measurement unless otherwise specified in the site-specific work plan. However, the presence and thickness of these items should be noted in the field book.

4. Measure the length of recovered soil in inches and record in the field book.

5. Continue by following the General Soil Sampling Procedures in Section 2.2.

Special Considerations for Split-spoon Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Slough* - Generally discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during insertion of the split spoon.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - The split-spoon sampler(s) is to be decontaminated between each sample. Within a borehole, the split spoon sample barrels must be cleaned between each sample - the driller typically has multiple barrels and can alternate between clean and dirty barrels so drilling progress is not affected by decontamination of the barrels. The augers should be decontaminated between boreholes (such as with high-pressure steam).

2.2.5 Shelby Tube/Thin-walled Sampling Methods

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses of physical properties such as shear strength, grain size distribution, density, hydraulic conductivity and permeability, to support engineering design, construction, and hydrogeologic characterizations at hazardous waste and other sites.

A typical Shelby tube is 30 inches in length, has a 3.0-inch OD (2.875-inch inside diameter) and may be constructed of steel, stainless steel, galvanized steel, or brass. They are typically attached to push heads constructed with a ball check to aid in holding the sample in the tube during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable. To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force from the drill rig. Shelby tube or thin-walled soil sampling should be conducted in accordance with ASTM Method D1587 *Practice for Thin-walled Tube Sampling of Soils for Geotechnical Purposes*.

After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition by following the direct-push sampling procedures in Section 2.2.3. If the sample is collected for geotechnical parameters, the tube is typically sealed, to maintain the sample in its relatively undisturbed state, capped, labeled appropriately (including sample ID, top end of sample, inches of recovery, etc.), and shipped to the appropriate geotechnical laboratory. The tube is typically stored in an upright position to maintain the integrity of the undisturbed sample. For geotechnical use, check with the laboratory prior to sampling to understand sample volume recoveries needed to perform the actual tests.

2.2.6 Sonic Drilling Sampling Methods

Sonic drilling/rotary vibratory drilling employs the use of high-frequency, resonant energy to advance a core barrel or casing into subsurface formations. Although sonic drilling is not technically a direct-push method of soil sampling, it is similar because soil sample collection from cores of recovered unconsolidated soil would follow the same procedures as described for direct-push methodologies. The soil core is extruded from the core barrel or casing into a plastic sleeve.

Sonic drilling is different than conventional drilling, as sonic drilling minimizes the friction between the borehole wall and the drilling tool by maintaining the resonance of the drill string with a sonic drill head. Typically the drilling method utilizes dual casings that independently resonate into the subsurface with an inner core barrel that is overrun by an outer casing.

Typically core runs are 10-feet. The core barrel is removed from the borehole and the core is extruded into a plastic sleeve. The plastic sleeve is placed on dedicated plastic sheeting. The plastic sleeve is then slit with a razor knife (or similar) vertically along the core run, exposing the soil inside.

The procedures for collecting soil samples from sonic cores are the same as the procedures presented for collecting soil samples from direct-push sampling methods in Section 2.2.3.

Special Considerations for Sonic Drilling Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- Sonic-generated soils are not undisturbed. The resonation of the core barrel during advancement energizes the skin of the sample immediately adjacent to the barrel, approximately ⅛ to ¼ inch around the OD of the sample. Heating of the soils is possible.
- Coring is always accomplished without air or fluids. Depending on site conditions, the outer casing may require adding some water to the borehole if heaving or flowing sands/sand and gravel are present.
- Resistance is not measured during core barrel advancement, as in split-spoon sampling where blow counts are measured. To collect conventional split-spoon samples and obtain blow counts, the sonic drill rigs can be outfitted with automatic hammers to advance split spoons or thin-walled push tubes, although the advantage of drilling speed with the sonic drilling technique is diminished.

2.2.7 Excavator Sampling Methods

A backhoe or excavator can be used to assist with soil sampling. This method is typically used during remedial excavation activities (to collect floor and sidewall samples within the excavation), test pit installation, or trenching operations. Test pit excavations are commonly completed to allow for greater observation of physical soil characteristics (e.g., stockpiles) and/or to further investigate buried suspect areas of concern (e.g., petroleum tanks, drums, waste, fill).

The following procedures are used for collecting soil samples excavated with a backhoe or excavator:

1. Prior to any excavation, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout.

2. For test pits or trench excavation, excavate in accordance with the site-specific work plan. Typically, this will be approximately 3 feet wide and approximately 1 foot deep below the cleared sampling location with the backhoe. Remedial excavations may be much wider and deeper. The work plan may also require that excavated soils be placed on plastic sheets or another impervious surface and protected from rain.

3. Refer to the site-specific work plan for the number of floor and/or sidewall samples, which is typically driven by the surface area and can vary depending on the governing regulatory agency.

4. Samples can be collected using a trowel, spoon, or coring device at the desired intervals. A clean shovel may be used to remove a 1 to 2- inch layer of soil from the vertical face of the pit that contacted the backhoe bucket and where soil sampling is planned. Scrape the vertical face at the point of sampling to remove any soil that may have fallen from above and to expose fresh soil for sampling. In many instances, soil sample locations within the excavation area are inaccessible (do not physically enter backhoe excavations to collect a sample). In these cases, soil samples can be collected directly from the backhoe bucket – use caution not to collect a soil sample from edges that may have come into contact with the backhoe bucket.

5. If VOC analyses are required, collect the sample in accordance with the procedures in Attachment A and/or the site-specific work plan. With a dedicated decontaminated spoon, or equivalent, place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

6. Abandon the pit or excavation according to applicable state regulations and the site-specific work plan. Generally, shallow excavations can simply be backfilled with the removed soil material.

Special Considerations for Excavator Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- Do not physically enter backhoe excavations to collect a sample if the excavations are unstable or not sloped and protected with shoring. A trench with non-cohesive soils (i.e., sand, saturated/wet muds, or flowing water at the base) is particularly susceptible to collapsing suddenly. Never enter a trench without a confined space entry permit, as required by OSHA regulations.
- Smearing is an important issue when sampling with a backhoe or excavator. Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.
- Loose paint, grease and rust should be removed and the backhoe bucket decontaminated prior to use for sample collection if the bucket will come in direct contact with the material to be sampled. Care should be taken to collect the soil sample from the center of the excavated material within the bucket (i.e., material that has not touched the bucket walls).

2.2.8 Stockpile Soil Sampling Methods

Stockpiled soils are typically sampled to characterize the soils for reuse or disposal. The stockpile sampling strategy used must consider the source of the soil and all available data, field observations, shape/dimensions and volume of the pile, and sampling frequency requirements established by oversight regulatory agencies or potential soil disposal facilities.

If the stockpile is known to be a representative mixture of soil with no known or suspected significant variability of contamination with depth in the pile, the stockpile sampling may be conducted according to the surface soil sampling method described in Section 2.2.1. However, if the soil characteristics are not known or are known or suspected to vary with depth in the pile, both surface soil and deeper subsurface soil samples will be required to properly characterize the soil pile.

A backhoe or excavator equipped with a bucket can be used to collect subsurface soil samples from stockpiles. This method is often preferred for collecting subsurface soil samples from a stockpile, since it allows the sampler greater opportunity to inspect the physical characteristics of the pile for any potential signs of variability for determining appropriate sample depths and locations.

Typically, based on the minimum required number of samples for the estimated stockpile volume, the stockpile is divided into the appropriate number of estimated volumes equal to that sample number. For example, if the specified sample frequency is 1 sample per 1,000 cubic yards (cy) and the estimated stockpile size is 4,000 cy, the stockpile would be broken down into approximately four equal volumes or quadrants. Grab VOC samples and composite non-VOC samples, as required, would then be collected from each of the areas for characterization of the stockpile.

2.3 Post-sampling Activities

1. After the samples have been collected, the sampling location may be marked with wooden stakes colored with highly visible spray paint and/or flagging in order to identify the sample location for surveying purposes. The sample and/or location identification should be written on the stake in indelible ink or marking pen. The sample location should be surveyed in the field with a GPS unit if not surveyed later by some other means. A sketch of the sampling locations should also be included in the field book.

2. Package the samples with bubble wrap and/or organic absorbent, as necessary.

3. Place the samples into a shipping container and cool to 4ºC. If wet ice is used to cool the samples, place the ice in double-bags to prevent water from the melting ice from damaging the samples during shipment.

4. Complete the COC form.

5. Decontaminate non-disposable sampling equipment.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following: field blank, equipment blank, trip blank, field duplicate, and matrix spike/matrix spike duplicates.

4.1 Duplicate Soil Sample Collection

The following procedures should be used for collecting duplicate soil samples:

1. For QC purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for soil sampling will be employed. However, a sample collection time will not be

included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book.

2. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC, VPH and/or GRO containers are filled and sealed, the duplicate sample VOC, VPH and/or GRO containers will also be filled and sealed. Duplicates for all parameters other than VOCs, VPH and GRO should be filled from the homogenized sample to ensure consistency between the sample and the duplicate. Following the order of collection specified for each set of containers (i.e., VOCs, VPH, GRO, semivolatile organic compounds [SVOCs], other organics and then inorganic compounds), the duplicate sample containers will be filled simultaneously with each parameter.

3. All collection and preservation procedures outlined for soil sampling will be followed for each duplicate sample.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the general sample collection information such as location, identification, and date/time in the field book or on a field data sheet. Typical field documentation recorded in a field book includes the following information:

- Sample identification number
- Sample location (description or sketch of the sample point)
- Sample depth interval
- GPS coordinates and coordinate system
- Time and date sample was collected
- Personnel performing the task
- Visual or sensory description of the sample (e.g., odors, staining)
- Brief soil descriptions (e.g., color, texture, appearance)
- Presence of any fill materials (e.g., concrete, asphalt, ash)
- Readings from field screening equipment (e.g., PID)
- Weather conditions during sampling
- Other pertinent observations including whether photographs were taken
- Sample collection equipment used
- Decontamination procedure
- Analytical parameters

Affix a properly completed label to each sample container.

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the site-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

ASTM Methods D1586 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soil,* D1587 *Practice for Thin-walled Tube Sampling of Soils for*

Geotechnical Purposes, ASTM D6169 *Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigation,* ASTM International, Most Current Version.

MassDEP, *Method for the Determination of Volatile Petroleum Hydrocarbons (VPH)*, May 2004.

U.S, EPA, SW-846 Method 5035A, *Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples*, Draft Revision 1, July 2002.

U.S. EPA Environmental Response Team, Soil Sampling SOP #2012, February 18, 2000.

U.S. EPA Science and Ecosystem Support Division, Soil Sampling Operating Procedure (SESDPROC-300-R2), December 20, 2011.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	SEPTEMBER 2013	NOT APPLICABLE
1	NOVEMBER 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

Attachment A:

Procedure for Collection of Samples for VOCs, VPH or GRO (SW-846 Method 5035A)

1.0 SAMPLING FOR VOLATILE ORGANIC COMPOUNDS IN SOIL BY EPA METHOD 5035/5035A

The following sampling protocol is recommended for site investigations assessing the extent of VOCs (including VPH and GRO) in soils at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the required detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

SW-846 Method 5035 provides instructions and options on the preservation of soil samples for low-level and high-level VOC analyses:

- Low-level (≤ 200 µg/kg) and
- High-level (> 200 µg/kg).

The choice of low-level or high-level analysis is determined by the requirements of the project. However, since the low-level method is only valid for a certain concentration range, a sample for analysis by the high-level method must also be collected to ensure quantification of all target analytes is possible, if needed.

The low-level method uses one or more of the following options for the sampling/preservation of soils:

- Soil sampled into a vial with a sodium bisulfate ($NaHSO_4$) solution.
- Soil collected in an En-Core® sampler and immediately shipped to the laboratory for further preservation (within 48 hours).
- Soil collected in a vial with organic-free water, sealed in the field, and shipped to the laboratory immediately in order to meet the method preservation requirement to freeze within 48 hours of collection.

Based on project-specific requirements, trip blanks may be recommended. Refer to the site-specific work plan for quality assurance (QA)/QC requirements.

1.1 Low-level Method (VOCs)

Option A - Direct sampling into En-Core® samplers

- Three 5 gram size En-Core® samplers for each sample.
- One nonpreserved container for moisture determination.

Option B - Direct sampling into vial with chemical preservative

- Two 5 gram size cores are added to volatile organic analysis (VOA) vials (one soil core is added to each of two VOA vials with sodium bisulfate solution) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). Once the vials are sealed in the field, these are not opened again.
- One nonpreserved container for moisture determination.

Option C - Direct sampling into vial with water (to be frozen at the laboratory)

- Two 5 gram size cores are added to VOA vials (one soil core is added to each of two VOA vials with water) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). Once the vials are sealed in the field, these are not opened again.
- One nonpreserved container for moisture determination.

1.2 High-level Method (VOC, VPH, GRO)

Option D - Direct sampling into En-Core® samplers

- One 5 gram size En-Core® sampler for each sample.
- One nonpreserved container for moisture determination.

Option E - Direct sampling into a methanol-preserved vial

- For VOCs: 5 or 10 grams of soil is added to a VOA vial (with 5 or 10 grams of methanol, respectively) for each sample using a Terra Core™ or other coring sampler (e.g., disposable syringe). This may also depend upon the regulatory agency (e.g., New Jersey Department of Environmental Protection requires 8 to 12 grams in 25 mL methanol or 5 grams in 10 mL methanol).
- For VPH or GRO: The coring device will be filled with 25 grams of undisturbed soil if 60-ml vials with 25 ml of methanol are used, or 15 grams of undisturbed soil if 40-ml vials with 15 ml of methanol are used. The goal is to have a 1:1 ratio of soil- to-methanol.
- One nonpreserved container for moisture determination.

1.3 Cautions and Potential Problems

1. Potential leaking sample containers for VOC, VPH and GRO analyses:

   Options for evaluating containers for leaking preservatives:

   a. When ordering pre-preserved sample containers, laboratories should be encouraged to mark the meniscus of the preservative on all sample containers. The preservative level should be checked before sampling as a quick check that there has not been any loss of liquid.
   b. Compare preservative level in multiple bottles and select one for comparison purposes to subsequent sample bottles.
   c. Weigh methanol-preserved sample containers prior to sampling. Sample containers found to have lost greater than 0.2 grams of methanol compared to their initial weight should not be used. In order to perform this option, initial container weights must be provided by the laboratory.

2. Potential methanol absorption:

   Soil may be encountered that absorbs all of the methanol preservative (e.g., organic-rich soil, fine-grain soil). These soils can absorb the methanol leaving no methanol extract for the laboratory to analyze. In these instances, the use of additional methanol is required. The laboratory must be contacted for sample containers with an increased volume of methanol.

Using a 1:2 ratio of soil to methanol will help to ensure that there will be adequate volume of methanol remaining for analysis. **NOTE: Additional methanol should not be added to the sample container by the sampler in the field. Containers with additional methanol must be obtained from the laboratory.**

3. Collection of samples with high moisture content:

   Soil samples with high (>50%) moisture content (e.g., sediments, soil samples below the water table) may prevent the attainment of the ideal 1:1 soil-to-preservative ratio. In these instances, depending on the data quality objectives, it may be necessary to evaluate the soil to determine what level in the disposable syringe corresponds to the required weight (typically 5 grams for VOCs and 15 or 25 grams for VPH). This can be performed by collecting several trial samples with disposable syringes. Weigh each trial sample and note the length of the soil in the syringe. These measurements would be used to determine how much soil in the syringe corresponds to 5 $\pm$ 0.5 grams (or the desired weight $\pm$ 0.5). All trial samples should be discarded and not used for analysis.

4. En-Core® sampler cautions:

   a. En-Core® samplers, or equivalent, should only be used on fine-grain or cohesive soils (soils that stay together in the En-Core® sampler and do not fall apart). En-Core® samplers should not be used to collect soil samples that consist of dry sand, gravel, or a mixture of gravel and fines, or samples with high moisture (e.g., sediments and soil samples below the water table). In the case of soil samples that consist of dry sand, gravel, or a mixture of gravel and fines, or samples with high moisture (e.g., sediments and soil samples below the water table), a stainless steel spatula or scoop should be used with field preservation techniques.
   b. The En-Core® sampler is a single-use device and cannot be decontaminated and reused.
   c. The volume of material collected in an En-Core® sampler should not cause excessive stress on the coring tool.
   d. The volume of material collected should not be so large that the sample easily falls apart during extrusion.
   e. The En-Core® sampler should not be used if any of the components are damaged as the seals may be compromised. Under no circumstances should any components be removed or disturbed.
   f. It is important to make sure air is not trapped behind the sample, as this could cause air to pass through the sample, resulting in a loss of VOCs, or it could cause the sample to be pushed prematurely from the coring tool.

5. Potential effervescence with use of sodium bisulfate as a preservative for low-level VOC analysis of soils:

   This method of preservation is not preferred and, therefore, is not outlined below. If it is used, the following cautions exist:

   a. Carbonaceous or strongly alkaline soils may cause potential effervescence when reacting with the sodium bisulfate and may result in a loss of VOCs and a shattered vial. If effervescence occurs, sodium bisulfate should not be used. The laboratory must be contacted and low-level preservation techniques, using water only, should be followed.

b. Loamy materials or materials containing decayed material may result in false positive results for acetone due to the interaction with the sodium bisulfate.

c. Some VOCs may be lost due to the resulting acidification when sodium bisulfate is used (e.g., styrene, 2-chloroethyl vinyl ether, acrylonitrile).

d. Some VOCs may be lost if the laboratory is using a heated purge in combination with the sodium bisulfate preservative (e.g., methyl tert butyl ether [MTBE] and other fuel oxygenates).

1.4 Sample Containers and VOC Sampling Equipment

- Method 5035A-compatible containers or kits (for VOCs, VPH and GRO). Preservatives may be required for some samples with certain variations of SW-846 method 5035A – consult the governing regulatory agency or principal analytical chemist to determine which preservatives are necessary.
  - Low-level VOCs: two 40-mL VOA vials pre-preserved with 5 mL organic-free water and also containing a magnetic stir bar.
  - High-level (or medium-level) VOCs: one 40-mL VOA vial pre-preserved with 5 or 10 mL of purge-and-trap-grade methanol. Volume will be dependent upon laboratory's preference or regulatory agency requirements (e.g., New Jersey Department of Environmental Protection prefers vials with 10 or 25 mL of purge-and-trap-grade methanol).
  - VPH and GRO: One 60-mL vial pre-preserved with 25 mL of purge-and-trap-grade methanol **or** One 40-mL VOA vial pre-preserved with 15 mL of purge-and-trap-grade methanol

    and
  - One glass container (or other appropriate container) with no preservative to allow the laboratory to perform the percent solids measurement. NOTE: The laboratory typically requires a minimum of 20 grams to perform this test. Therefore, submitting a sample size less than 4 ounces may be acceptable. This additional container will not be required if the sample is also being submitted for other non-VOC parameters.

- En-Core® samplers, or equivalent, for VOC, VPH and/or GRO analysis:
  - High-level VOC or GRO analysis: one 5-gram En-Core® sampler.
  - Low-level VOC analysis: two 5-gram En-Core® samplers.
  - VPH, GRO or toxicity characteristic leaching procedure (TCLP) VOC analysis: one 25-gram En-Core® sampler.

- Disposable plastic syringes or Terra Core™ samplers.

- Foam VOC vial holders.

- Portable digital scale (accurate to ± 0.01 grams) with calibration weights.

2.0 COLLECTION OF SAMPLES USING EN-CORE® SAMPLERS, OR EQUIVALENT

- The sample will be collected using an En-Core® sampler, or equivalent, as soon as possible after the soil has been exposed to the atmosphere.
- Check that the En-Core® sampler, or equivalent, is full using both of the following procedures:
    a. Be sure that the back o-ring on the plunger can be seen when looking through the viewing hole on the handle. This will mean that the soil has pushed the plunger fully to the back.
    b. The plunger can only be rotated when it is fully pushed to the back of the body. Therefore, it is important to twist the plunger to guarantee that the soil has filled the sampler and the back o-rings have sealed.
- Immediately seal the En-Core® sampler, or equivalent. Be sure to twist the cap as it is pushed on. The cap is properly sealed when the two locking arms are completely and symmetrically over the body ridge.
- The samples must be shipped to a laboratory within 24 hours of sampling to ensure the 48-hour hold time for preservation will be met.
- In the event that a field screening technique (instrument reading or visual staining of the soil) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.
- If samples are collected for only VOC and VPH analyses, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

3.0 COLLECTION OF SAMPLES USING FIELD PRESERVATION

- Samples for VOCs will be collected as soon as possible after the soil has been exposed to the atmosphere.
- Samples for VOCs will be collected first (prior to collection of samples for other parameters) using an open-barrel disposable syringe, Terra Core™ sampler, or equivalent. In the case of soil samples that consist of dry sand, gravel, or a mixture of gravel and fines, or samples with high moisture (e.g., sediments and soil samples below the water table), an open-barrel disposable syringe may not be practical; a stainless steel spatula or scoop can be used with field preservation techniques.
- Soil samples for VOC analyses should **never** be homogenized.
- Each pre-preserved sample container will be weighed prior to sample collection, and the container/preservative weight will be recorded. This procedure will generally be performed by the laboratory prior to shipping the containers to the field.
- Depending upon project requirements, samples for VOC analysis will be collected as low-level, high-level, or both.

A. Low-level VOCs

1. The syringe will be filled with undisturbed soil of the following volume: 5 grams of soil.

   As an option to the syringes, 5-gram Terra Core™ samplers, or equivalent, can be used. The goal is to have a 1:1 ratio of soil- to- preservative.

2. The soil will be extruded into a pre-preserved VOA vial containing a magnetic stir bar and 5 mL organic-free water. This will be done in replicate.

3. Any sand grains present on the container rim or cap must be removed to ensure an air-tight seal of the vial. The VOA vial will be capped quickly and labeled with the sample ID, date, and time of collection. Labels should not be written on the cap of the vial.

4. Gently swirl sample to break up the soil aggregate, if necessary, until the soil is covered with preservative. It is imperative that the soil sample be completely immersed in the preservative solution.

5. In the event that a field screening technique (instrument reading or visual staining of the soil) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.

6. If samples are collected for only VOC analysis, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

B. High-level VOCs, VPH, or GRO

1. High-level VOCs: The syringe will be filled with undisturbed soil of the following volume: 5 or 10 grams of soil for high-level analysis (added to the 5 or 10 ml of methanol, respectively). This may also depend upon the regulatory agency (e.g., New Jersey Department of Environmental Protection requires 8 to 12 grams in 25 mL methanol or 5 grams in 10 mL methanol).

   VPH or GRO: The syringe will be filled with 25 grams of undisturbed soil if 60-ml vials with 25 ml of methanol are used, or 15 grams of undisturbed soil if 40-ml vials with 15 ml of methanol are used. The goal is to have a 1:1 ratio of soil- to- methanol.

   As an option to the syringes, 5-gram Terra Core™ samplers, or equivalent, can be used. Typically, the goal is to have a 1:1 ratio of soil- to- preservative.

2. The sample will be extruded into a VOA vial containing purge-and-trap grade methanol

3. Any sand grains present on the container rim or cap must be removed to ensure an air-tight seal of the vial. The VOA vial will be capped quickly and labeled with the sample ID, date, and time of collection. Labels should not be written on the cap of the vial.

4. Gently swirl sample to break up the soil aggregate, if necessary, until the soil is covered with preservative. It is imperative that the soil sample be completely immersed in the preservative solution.

5. In the event that a field screening technique (instrument reading or visual staining of the soil) indicates the possible presence of VOCs or hydrocarbons, note the observations or instrument readings in the field book. If the field screening technique does not indicate the presence of VOCs, this should also be noted.

6. Methanol is considered to be a hazardous material by the US Department of Transportation (DOT) and the International Air Transportation Association (IATA). Shipments containing methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the most current edition of the IATA Dangerous Goods Regulations. The volumes of methanol recommended in the VOC method fall under the small quantity exemption of 49 CFR section 173.4. Refer to Attachment B for further details.

7. If samples are collected for only VOC analysis, a separate aliquot must be collected in an unpreserved container in order for the laboratory to perform a dry weight determination.

Attachment B:

Shipping Methanol-preserved Samples

Shipping of Hazardous Materials

Methanol is considered a hazardous material by the US Department of Transportation (DOT) and the International Air Transport Association (IATA). Shipments of methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the most current edition of the IATA Dangerous Goods Regulations. Consult these documents or your shipping company for complete details.

Small Quantity Exemption

The volumes of methanol recommended in the high-level VOC, VPH and GRO methods fall under the small quantity exemption of 49 CFR section 173.4. To qualify for this exemption, all of the following conditions must be met:

◊ the maximum volume of methanol in each sample container must not exceed 30 mL
◊ the sample container must not be full of methanol
◊ the sample container must be securely packed and cushioned in an upright position and be surrounded by a sorbent material capable of absorbing spills from leaks or breakage of sample containers
◊ the package weight must not exceed 64 pounds
◊ the volume of methanol per shipping container must not exceed 500 mL
◊ the packaging and shipping container must be strong enough to hold up to the intended use
◊ the package must not be opened or altered while in transit
◊ the shipper must mark the shipping container as follows:

“*This package conforms to 49 CFR 173.4*”

When shipping domestically by Federal Express via ground or air, the following rules apply:

◊ follow the inner packaging requirements of 49 CFR 173.4
◊ no labels, placards, up arrows, or dangerous goods shipping papers are required
◊ if the Federal Express airbill has a shipper’s declaration for hazardous goods on it, check the Yes box under *Shipper’s Declaration not Required*

When shipping internationally by Federal Express, the following rules apply:

◊ follow the inner packaging requirements of 49 CFR 173.4
◊ use dangerous goods shipping papers
◊ apply orientation arrows on opposite vertical sides on the exterior of the package

Shipping Papers for International Shipments

<u>International shipments must be</u> accompanied by dangerous goods shipping papers that include the following:

Proper Shipping Name:	Methyl Alcohol
Hazardous Class:	Flammable Liquid
Identification Number:	UN1230
Total Quantity:	*(mL methanol/container x the number of containers)*
Emergency Response Info:	Methanol MSDS attached
Emergency Response Phone:	1-800-424-9300

Attachment C:

SOP Fact Sheet

SOIL SAMPLING PROCEDURES

PURPOSE AND OBJECTIVE

Soil sampling is conducted in order to obtain a representative sample for laboratory analysis of constituents of interest at a given site. Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type.

WHAT TO BRING

- Stainless steel mixing bowl and stainless steel spoon or spatula
- Hand auger or post hole auger, if applicable
- Stainless steel trowel and/or shovel
- Tape measure, folding ruler
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags
- Field book and/or boring log
- Camera
- Maps/site plan
- Survey equipment and/or GPS and/or other means of measuring sample locations
- Indelible marking pens or markers
- Sample coolers, sample containers (including any necessary En-Core® samplers, disposable plastic syringes or Terra Core™ samplers), sample container labels, COCs, and ice
- Bubble wrap and Zip-loc® plastic bags (for ice and COCs)
- Equipment decontamination supplies
- Any required field screening equipment, such as PID

OFFICE

- Prepare/update the HASP; make sure the field team is familiar with the latest version.
- Discuss the objective for the soil sampling program with the Project Manager and/or the field lead. Discuss sample order, collection method, designation, analytical parameters, turn-around times, laboratory, etc.
  - Are the soil cuttings to be containerized in drums or returned to borehole?
  - Volume of soil required for each sample?
  - QA/QC sample collection?
  - Field decontamination required?
- Verify whether police traffic control will be required for work completed on or near public roadways.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure, test equipment and make sure it is in proper working order.
- Verify that a utility survey/mark-out has been performed to ensure that sample locations are clear of overhead and buried utilities. Obtain a copy of the markout ticket or confirmation number. Additionally, a private geophysical sub-surface survey may be necessary.
- Review sample bottle order for accuracy and completeness.
- Make sure soil boring locations (or specific sampling areas) are clearly identified on figure and that soil boring and sample designations are understood.

ON-SITE

- Verify that underground utilities have been marked out and that the markouts are clear. Stay at least two feet away from any marked utility. Identify if any overhead obstructions or limited access areas exist near proposed borings and contact the Project Manager if any proposed locations need to be moved. Sketch/photograph markout locations.
- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.

GENERAL SOIL SAMPLING PROCEDURES

- Refer to other TRC SOPs for the proper procedures for classifying soil samples and for screening of samples for VOCs.
- Perform any required field screening in situ or immediately upon retrieval of the soil sample from the subsurface.

SOIL SAMPLING PROCEDURES

- Samples for VOC, VPH or GRO analysis are then collected as soon as possible after the soil has been exposed to the atmosphere and prior to sample collection for other analyses.
  - **These samples are NOT homogenized.**
  - These samples are generally collected using an open-barrel disposable syringe, a Terra Core™ sampler, or an En-Core® sampler, or equivalent. Refer to the site-specific work plan or governing regulatory authority for preservation requirements for VOC, VPH or GRO analysis and Attachment A of RMD 003.
- After collecting the sample for VOC analysis, the sample portion for the remaining analysis should be well homogenized, in situ (if possible, such as with surface soil sampling), or in a decontaminated stainless steel bowl or disposable new aluminum pie pan to ensure that the sample is as representative as possible of the sample media.
- Stones, gravel, vegetation or debris (such as concrete, asphalt, ash or slag) should be removed from the soil sample as much as practical prior to placement in sample containers, unless these matrices are part of the overall characterization program.
- Transfer to sample containers using clean new or decontaminated spoons/scoops.
- Filling of the sample bottles should be completed immediately after sample collection to minimize losses due to volatilization and biodegradation. Soil classification can be completed following sample collection.
- Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.
- Make sure ALL sample containers are clearly labeled with the site name, sample date, sample collection time and sample designation including depth in indelible ink. Samples should be entered on the COC as they are collected. Make sure to clearly identify requested sample analyses on the COC.
- Labeled samples should be immediately put into a cooler with ice; sample coolers should always be kept within eyesight or stored within the cab of the vehicle or other secured place such as a locked office.
- Be aware of sample holding times, and arrange for samples to be in the laboratory's possession accordingly.
- Restore the sampling location to grade in accordance with applicable state regulations and/or the site-specific work plan. Options include backfilling the sample location with the remaining removed soil, bentonite pellets or, cement/bentonite grout depending on site conditions and patching the surface to match the surrounding area (e.g., topsoil with grass seed, asphalt or concrete patch), as necessary.
- Record locations of soil borings/samples in the field book by sketching a map and/or providing a description of the location. When measuring locations of soil borings/samples, always use fixed landmarks such as buildings, fences, curbs, etc.
- Decontaminate sampling equipment in accordance with TRC's SOP on equipment decontamination.
- Ensure any IDW is appropriately managed. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

SURFACE SOIL SAMPLING PROCEDURES

The depth of surface soil samples are typically collected from 0-6 in. or 0-12 in. and will be determined on a site-specific basis and may be influenced by site-specific conditions. The following procedure should be used for surface soil sampling:

- If a thick, matted root zone, leaf layer, gravel, surface debris, concrete, etc. is present at or near the surface, it should be carefully removed using clean decontaminated tools before the soil sample is collected. The presence and thickness of any such material should be recorded in the field book for each location. The depth measurement for the soil sample begins at the top of the soil horizon, immediately following any such removed materials.
- A decontaminated stainless steel spoon, scoop or trowel is typically used for surface soil sampling depths from 0 to 12 inches bgs. A hand auger or shovel may also be used to dig down to the desired depth and then after careful removal of the dug soils from the hole, a decontaminated stainless steel spoon, scoop or trowel is used to collect the soil sample from the bottom of the hole for laboratory chemical analysis.
- Continue by following the General Soil Sampling Procedures.

HAND AUGER SAMPLING PROCEDURES

Hand augers may be used to advance boreholes and collect soil samples in shallow subsurface intervals. Often, 4-inch diameter stainless steel auger buckets with cutting heads are used. The auger is advanced by simultaneously pushing and turning using an attached T-handle with extensions (if needed). Auger holes are advanced one bucket at a time until the appropriate sample depth is achieved. The following procedure should be used for hand auger sampling:

- Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the borehole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding rod extensions. It also facilitates refilling the borehole and avoids possible contamination of the surrounding area.

SOIL SAMPLING PROCEDURES

- When the sample depth is reached, remove the bucket used to advance the borehole and attach a decontaminated or clean bucket. Place the clean auger bucket in the borehole, advance the clean auger bucket to fill it with the soil sample and then carefully remove the clean auger bucket.
- If VOC analysis is to be performed, collect a sample directly at the bottom of the boring, if within reach, and not from the auger bucket. If not within reach, collect the sample directly from the auger bucket or from minimally disturbed material immediately after the auger bucket is emptied.
- Continue by following the General Soil Sampling Procedures.

DIRECT PUSH/SPLIT SPOON/SONIC DRILLING SAMPLING PROCEDURES

For some soil investigations, soil logs provide justification for sample locations and intervals so be descriptive and precise.

- The driller will advance the soil sampler (macrocore, split spoon, sonic casing, etc.) which will then be given to the sampler - confirm with driller which end is top and which end is bottom. Record the time of core collection in the field book (military time). Begin the soil record by indicating the soil boring location, followed by the depth interval in feet bgs [e.g., B-1/0-4].
- Record the blow count per six inch interval when collecting split-spoon samplers with hollow stem auger rig. The drillers will keep the count and repeat them to you. If refusal is encountered, the count is recorded in the book as "# of hammer blows / depth in inches the spoon is driven" (e.g., 50/3 – means 50 blows of the hammer advanced the spoon 3 inches).
- Measurement of vertical depth should start from the top of soil; surface asphalt, surficial concrete slabs or gravel sub-base should be excluded from depth measurement (however, the presence and thickness of these items should be noted in the field book).
- Measure the length of recovered soil in inches and record in the field book.
- Continue by following the General Soil Sampling Procedures. If a specific depth interval is targeted for sampling, be sure to account for percent recovery when selecting the sample interval.

SHELBY TUBE SAMPLING PROCEDURES

A typical Shelby tube is 30 inches in length, has a 3.0-inch OD (2.875-inch inside diameter) and may be constructed of steel, stainless steel, galvanized steel, or brass, depending on the specific application. They are typically attached to push heads constructed with a ball check to aid in holding the sample in the tube during retrieval. To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force from the drill rig. After retrieval to the surface, the tube containing the sample is then removed from the sampler head.

- If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition by following the direct-push sampling procedures.
- If the sample is collected for geotechnical parameters, the tube is typically sealed, to maintain the sample in its relatively undisturbed state, capped, labeled appropriately (including sample ID, top end of sample, inches of recovery, etc.), and shipped to the appropriate geotechnical laboratory. The tube is typically stored in an upright position to maintain the integrity of the undisturbed sample.
- For geotechnical use, check with the laboratory prior to sampling to understand sample volume recoveries needed to perform the actual tests.

EXCAVATOR SAMPLING PROCEDURES

A backhoe or excavator can be used to assist with soil sampling such as during remedial excavation activities (to collect floor and sidewall samples within the excavation), test pit installation, or trenching operations. Test pit excavations are commonly completed to allow for greater observation of physical soil characteristics (e.g., stockpiles) and/or to further investigate buried suspect areas of concern (e.g., petroleum tanks, drums, waste, fill). The following procedures are used for collecting soil samples excavated with a backhoe or excavator:

- For test pits or trench excavation, excavate in accordance with the site-specific work plan. Typically, this will be approximately 3 feet wide and approximately 1 foot deep below the cleared sampling location with the backhoe. Remedial excavations may be much wider and deeper. The work plan may also require that excavated soils be placed on plastic sheets or another impervious surface and protected from rain.
- Refer to the site-specific work plan for the number of floor and/or sidewall samples, which is typically driven by the surface area and can vary depending on the governing regulatory agency.
- Samples can be collected using a trowel, spoon, or coring device at the desired intervals. A clean shovel may be used to remove a 1 to 2- inch layer of soil from the vertical face of the pit that contacted the backhoe bucket and where soil sampling is planned. Scrape the vertical face at the point of sampling to remove any soil that may have fallen from above and to expose fresh soil for sampling. In many instances, soil sample locations within the excavation area are inaccessible (do not physically enter backhoe excavations to collect a sample). In these cases, soil samples can be collected directly from the backhoe bucket – use caution not to collect a soil sample from edges that may have come into contact with the backhoe bucket.
- Continue by following the General Soil Sampling Procedures.
- Abandon the pit or excavation according to applicable state regulations and the site-specific work plan. Generally, shallow excavations can simply be backfilled with the removed soil material.

SOIL SAMPLING PROCEDURES

STOCKPILE SOIL SAMPLING PROCEDURES

Stockpiled soils are typically sampled to characterize the soils for reuse or disposal. The stockpile sampling strategy used must consider the source of the soil and all available data, field observations, shape/dimensions and volume of the pile, and sampling frequency requirements established by oversight regulatory agencies or potential soil disposal facilities.

If the stockpile is known to be a representative mixture of soil with no known or suspected significant variability of contamination with depth in the pile, the stockpile sampling may be conducted according to the surface soil sampling method described above. However, if the soil characteristics are not known or are known or suspected to vary with depth in the pile, both surface soil and deeper subsurface soil samples will be required to properly characterize the soil pile. Based on the minimum required number of samples for the estimated stockpile volume, the stockpile is divided into the appropriate number of estimated volumes equal to that sample number.

POST SAMPLING ACTIVITIES

- After the samples have been collected, the sampling location may be marked with wooden stakes colored with highly visible spray paint and/or flagging with the sample location identification written on the stake in indelible ink. The sample location should be surveyed in the field with a GPS unit if not surveyed later by some other means. A sketch of the sampling locations should also be included in the field book.
- Package the samples with bubble wrap as necessary.
- Place the samples into a shipping container and cool to 4°C. If wet ice is used to cool the samples, place the ice in double-bags to prevent water from the melting ice from damaging the samples during shipment.
- Complete and cross check the COC form.
- Decontaminate non-disposable sampling equipment.

DOs AND DO NOTs OF SOIL SAMPLING

DOs:

- No matter the work plan or the site, DO have the following items when going into the field:
  - Site-Specific HASP
  - Steel-toed boots
  - Field book and a pen with indelible ink.
  - Nitrile gloves
  - Business cards
- DO review soil boring logs or cross sections from previous sampling events, if available.
- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least twice during the work day to update them. Even if everything is fine and there are no questions, call with an update. It is also recommended to call when sampling is winding down for the day to make sure that the work plan has been fully implemented and there are no additional tasks to complete.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO decontaminate any heavy equipment used for the advancement of sampling devices by steam cleaning or high pressure/hot water wash prior to and between sample locations. This would include, but is not limited to auger flights, drill rods, backhoe buckets and other respective accessories.
- DO review and count the sample bottles and compare to the COC prior to leaving the site.
- DO record sampler type (e.g., macrocore, split spoon, etc.) and boring method (e.g., direct push, hammer, etc.) in the field book.
- DO record the hammer weight, the distance of the hammer drop and the method for hammer lift (i.e., cathead and rope, hydraulic, etc.) in the field book at least once per day when collecting split-spoon samples with a drill rig.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc. call the Project Manager if there is an issue.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT include any upper soils which may "fall" as a result of the open borehole caving in (slough) when recording recovery.
- DO NOT use general terms such as "Fill" or "Till" as a sole description for layers – always give detailed description of soil components.

Attachment D:

SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® during sample handling or mobilization/demobilization. This includes waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use low density polyethylene (LDPE)[1] or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil • Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Field notes should be attached to the project-specific field book or folder upon returning to the office. • Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable. • Do not use Post-It Notes during sample handling or mobilization/ demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan (HASP) prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
	• Personnel involved with sample collection and handling should wear nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up at a soil sampling location.
1.6	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
2.2	• LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. Do not homogenize soil in aluminum pie pans. Use a decontaminated stainless steel bowl. • Stainless steel tools should not be wrapped in aluminum foil after decontaminating prior to and in between uses. • Homogenize the soil sample in a decontaminated, stainless steel bowl and place in an appropriate laboratory-provided sample container (as listed above) following the collection of VOC, VPH or GRO samples.
2.2.3	Do not use Teflon® liners for direct push sampling methods. Cellulose acetate butyrate (CAB) liners are acceptable.
2.2.7	Homogenize the soil sample in a decontaminated, stainless steel bowl and place in an appropriate laboratory-provided sample container (as listed above) following the collection of VOC, VPH or GRO samples.
2.3	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable.

[1]PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces.

Title: **Water Level and Product Measurements**		Procedure Number: **ECR 004**	
		Revision Number: **1**	
		Effective Date: **December 2016**	
Authorization Signatures			
		Elizabeth Denly	
Technical Reviewer Rebecca Armes	Date 12/15/16	ECR Practice Quality Coordinator Elizabeth Denly	Date 12/15/16

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1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting water level, separate-phase product, and/or total well depth measurements in monitoring wells, piezometers, and boreholes during field investigations.

1.2 Summary of Method

Depth-to-water (DTW) measurements are used to evaluate pressure and/or elevation changes within the aquifer. The procedure involves using a water level indicator capable of an accuracy of ±0.01 feet, or a similar piece of equipment, to measure the DTW in a monitoring well, piezometer, or borehole from a set reference point. When used in conjunction with an accurate site elevation survey, DTW data can be converted to potentiometric surface elevations to support groundwater flow direction analysis, as well as other aquifer characteristics. In addition, pressure changes recorded in a well during a slug, pumping, or packer test can be used to determine aquifer characteristics, such as hydraulic conductivity and storage parameters.

It is also a good practice to gauge the total depth of a monitoring well while taking water levels. This practice can help confirm: 1) the correct well in a cluster of wells screened at different depths; 2) that the well is clear of obstructions; 3) whether the well may be silting up and need further development; and 4) the correct purge volume for a well when sampling. Total depth measurements in a well may be necessary when TRC is taking over project work at a site with existing monitoring wells or the site wells have not been accessed for a significant amount of time.

The objective of separate-phase product measurements is to obtain measurements of the thickness of separate-phase product in the water column. The thickness of both dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) can be determined using an oil/water interface probe. It should be noted that the thickness of LNAPL or DNAPL in a well ("apparent thickness") most likely differs from the thickness in the formation ("actual thickness").

- For LNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the underlying groundwater from a set reference point. The difference between these two measurements is the thickness of the LNAPL in the well.

- For DNAPL, the procedure involves measuring the depth to the separate-phase product and the depth to the bottom of the well, borehole, etc. The difference between these two measurements is the thickness of the DNAPL in the well.

1.3 Equipment

The following list of equipment may be utilized when conducting water level and separate-phase product measurements. Site-specific conditions may warrant the use of additional items or deletion of items from this list. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details.

- Appropriate level of personal protection
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and monitoring form
- Well keys
- Socket-wrench
- Containers to hold water and isopropanol for calibration
- Tap water
- Isopropanol
- Previous measurement data (if available)
- Precision ruler or measuring tape
- Permanent marker (e.g., Sharpie®)
- Decontamination supplies

1.4 Definitions

Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and, therefore, floats on the surface of the water.
Monitoring Well	A well made from a polyvinyl chloride (PVC) pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.

Separate-phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and has a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Total Depth of Well	Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific health and safety plan (HASP). TRC personnel will use the appropriate level of personal protective equipment (PPE) as defined in the HASP.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

1.6 Cautions and Potential Problems

Special care should be taken when using equipment if PFAS are known or suspected to be present. Please refer to Attachment D for details.

- DTW measurements of all wells in a water level survey should be collected within the shortest amount of time possible but, at a minimum, within a 24-hour period to ensure near contemporaneous data collection during a groundwater elevation recording event. However, note that certain conditions may produce relatively rapid changes in groundwater elevations, which might necessitate collecting readings over a shorter time period. Such conditions should be noted in the field book. Rapid groundwater elevation changes may occur due to:
  - Rapid changes in atmospheric pressure
  - Variable pumping of nearby wells
  - Precipitation events
  - Tidal influences
  - Rapid changes in nearby surface water levels (e.g., dam release, upstream thunderstorm)
- Allow water levels in newly installed wells to stabilize for approximately 24 hours before taking measurements for the purpose of a water level survey. Recovery might take longer in wells installed in low permeability formations.
- Because the tops of monitoring wells and piezometers are often cut unevenly, be sure to take DTW measurements from a pre-marked or notched spot on the well to ensure consistent data collection over time. Since land survey vertical elevation measurements are generally taken

from the highest point on the well casing (i.e., where survey rod rests), this point should also be marked and used for water level measurements. If the tops of the monitoring wells and piezometers are not marked, the DTW measurement should be taken from the north side of the riser and the location marked on the casing top edge.

- To limit the possibility of cross contamination, DTW measurements should be collected in order from the least to the most contaminated wells and piezometers when contamination is known or suspected. Be sure to decontaminate the entire length of the submerged tape between well measurements to reduce the potential for cross contamination. Refer to Attachment D and ECR SOP 010 for decontamination of PFAS. Some wells with NAPL or excessive condensation may have residues on the side of the riser that may also contaminate the tape.
- If the presence of NAPL is suspected at a site, an oil/water interface probe should be used to conduct water level measurements. When DNAPL is a suspected contaminant characteristic at a site, the interface probe should be lowered to the bottom of the well until DNAPL is encountered, if present.
- NAPL may foul the probe and could cause a delayed response when going from NAPL to water. Resolution may require taking repeated measurements by raising and/or lowering the probe through the interface.
- Most water level meters have a "sensitivity" setting, which is often located on the on/off dial. The sensitivity setting may need adjustment depending on the site water chemistry.
- Excessive condensation on the inside well materials may cause the tape to stick on the well casing and/or cause a false reading above the water level. This is especially true of deeper wells. Previous elevation data should be consulted to determine if a reading is consistent and plausible for that well. The above mentioned sensitivity adjustment can be used to compensate. In some cases, the line may have to be weighted to remedy the line sticking to the casing.
- Tight well caps and low permeability formations may not have allowed the potentiometric surface to equilibrate in the well after seasonal, tidal or other area groundwater level fluctuations. If this is the case, allow the wells to equilibrate before collecting measurements by taking readings several minutes after removing the well plug; in addition, re-measure the first well after the last well to verify that the water level is not fluctuating. Another round of water levels may need to be collected if a significant discrepancy from the first set of measurements is observed; this should be discussed with the Project Manager. If this is a concern, vented well caps or plugs may need to be used.
- In some instances, artesian well conditions may exist, where the potentiometric surface is higher in elevation than the top of the well casing (TOC). In these situations, it is pertinent to note the water level elevation as above the TOC or add a known length of riser pipe in order to measure an actual elevation. Once the water level has equilibrated in the riser pipe, the same procedures can be followed for measuring water level when separate-phase product is not suspected. Note that when converting the DTW measurement to an elevation, the riser pipe length needs to be added to the surveyed TOC.

- Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps, and the same water level indicator should be used for all measurements if possible. All wells should be measured within the minimum possible time. This is particularly important in areas with potential tidal influences.

- If more than one measuring device must be used for multiple wells across an area with a shallow groundwater gradient, the "zero calibration check" (see Section 2.1.1) becomes especially important.

- If the monitoring well or piezometer is secured with an air- and water-tight lockable cap, caution should be taken when removing the cap due to the possible buildup of pressure in the well casing. Try to ease the cap off and relieve the pressure slowly in order to prevent injury. Do not stand or lean over top of well when releasing cap.

- Flush-mounted wells may be subject to water collection in the well can around the top of the riser pipe. In such instances, sufficient water should be evacuated from the well can prior to removing the well cap to ensure that ambient water does not enter the riser. The condition should be documented and the potential need for repair discussed with the Project Manager.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Workers (HAZWOPER)
- 8-hour annual refresher training

2.0 PROCEDURES

To be useful for establishing groundwater gradient, the reference point should be tied with a known vertical datum, such as the National Geodetic Vertical Datum (NGVD), or a local datum (e.g., site-specific arbitrary datum).

Water levels should be allowed to equilibrate prior to measurement after removing sealing well caps. There are no set guidelines, and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology, and project objectives.

If available, prior site water and product level measurement data should be reviewed and available to field personnel during the collection of new data for direct comparison to aid in identifying and resolving potential measurement errors while in the field.

When measuring well depths with an electronic water level indicator, measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth.

The following procedures must be followed during the collection of water level and product measurements. Procedures may vary depending on the equipment used and contaminants present at the site. Special care should be taken when using measurement equipment if PFAS are known or suspected to be present. Please refer to Attachment D for details.

2.1 Calibration and Operational Checks

Refer to the project's Quality Assurance Project Plan (QAPP) for calibration frequency and any site-specific calibration procedures for water and separate-phase product level meters. Calibration of the meters is optional; the need for calibration and the frequency of calibration will be dependent upon the meter used and project-specific data quality objectives. Operational checks of meters will be performed prior to use in the field at the start of each day and several times throughout the day, as appropriate.

2.1.1 Operational Check of Water Level Meters

1. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

2. Release the start/test button and lower the water level probe into a container filled with tap water until the meter audible indicator sounds or visual indicator light turns on. During this check, set sensitivity adjustment (if provided) to highest setting, then decrease if necessary (e.g., saline water).

Inspect the measuring tape and water level probe connection for any signs of visible damage (e.g., cuts, kinks, separating splices). If the tape appears damaged at the connection to the probe, while the meter is sounding, perform the procedure in Section 2.1.2.

2.1.2 Calibration of Water Level Meters

1. While the meter is sounding from the procedure used in Section 2.1.1, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.

2. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager. If necessary, repair and/or replace the water level meter.

2.1.3 Calibration and Operational Check of Oil/Water Interface Meters

1. Oil/water interface meters will have one distinguishing sound and/or colored light to represent detection of water and a separate distinguishing sound to represent detection of separate-phase product. Read the instrument manufacturer's operations manual to determine the instrument's audible sound or light differentiation for water and separate-phase product (e.g., continuous beep for product and intermittent beep for water).

2. Push the Start or Test button (typically provided) on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate (if equipped).

3. Water Level Sensor Operational and Calibration Checks

   a. Lower the water level probe into a container filled with tap water until the appropriate sound for water is heard as determined in Step 1.
   b. While the meter is sounding, use a ruler or measuring tape to measure the distance between the water surface and the 1-foot increment mark on the water level tape.
   c. Check that the 1-foot increment is actually 1 foot from the water surface. Note any discrepancy in the field book and discuss with the Project Manager.

4. Oil Level Sensor Operational and Calibration Checks

   a. If the operation or calibration of the oil level probe is suspected to be faulty, consult with the meter manufacturer for additional troubleshooting.

2.2 Procedures for Measuring Depth to Water When Separate-phase Product is Not Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book or on the water level monitoring form or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated water level meter, turn on the meter, check the audible/visual indicator (push the "Test" button), reel the electronic probe into the well riser (with the increments visible) slowly until the meter sounds.

5. Grasp the tape with hand, withdraw the tape, and lower it again slowly until the sound is again audible. Check the DTW on the tape and make a mental note of the depth to within 0.01 feet.

6. Lower the probe again slowly and repeat the measurement for precision. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in

Step #3 to the nearest 0.01 feet. If measuring the total depth of the well, proceed to Section 2.4).

7. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications. Refer to Attachment D and ECR SOP 010, Equipment Decontamination, for decontamination procedures for sites with known or suspected PFAS contamination.

2.3 Procedure for Measuring Depth to Water and Product Levels When Separate-phase Product is Suspected

If possible, and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated. Additionally, allow sufficient time for each monitoring well or piezometer to equilibrate after removing the protective cap prior to taking readings.

1. Record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.), equipment being used, and the current weather conditions in the field book, water level monitoring form, or well inspection report.

2. Use HASP-specified gloves. Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure build up that may have occurred in the well casing. Follow HASP requirements for well head and breathing zone air monitoring.

3. Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book or on the water level monitoring form (e.g., top of riser or top of casing).

4. Using a previously decontaminated oil/water interface probe, turn on the meter, check the audible indicator, and slowly reel the electronic probe into the well riser (with the increments visible) until the appropriate sound for water or separate-phase product is heard as determined in Section 2.1.3.

5. If water is encountered first (as determined by the audible sound on the meter, which represents water), follow steps 5 and 6 from Section 2.2. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step 3 to the nearest 0.01 feet.

6. If water is encountered first and DNAPL is suspected, continue lowering the probe until product is encountered (as determined by the audible sound on the meter, which represents product). In the field book or on the water level monitoring form, record the depth to product from the measuring point noted in Step #3.

7. Calculate the thickness of the DNAPL in the well using the following equation:

   (Total depth of well) - (Depth to product) = DNAPL thickness

8. If LNAPL is encountered before water, record the depth to product from the measuring point noted in Step #3 in the field book and continue lowering the probe until water is encountered.

   NOTE: For LNAPL, it is necessary to take both the air/product interface measurement on the way down into the product and the water/product interface measurement on the way back up. This is required when passing through product into water, since some product may adhere to the probe sensors due to surface tension and, as a result, a greater product thickness measurement may be erroneously obtained. Therefore, when LNAPL is detected, the probe should be lightly shaken or raised and lowered rapidly in a short vertical motion while the probe is within the water column to remove any product that may have been carried down with the probe. After passing through the product, the water/product interface should then be measured as the probe is raised very slowly back up from the underlying water into the product. Once the interface is detected, the probe can be raised and lowered in small increments to precisely determine the interface and obtain accurate measurements. Repeat these measurements as needed to confirm water/product interfaces and product thickness on multiple measurements.

9. In the field book or on the water level monitoring form, record the DTW from the measuring point noted in Step #3. If measuring the total depth of the well, proceed to Section 2.4.

10. Calculate the thickness of the LNAPL in the well using the following equation:

    (DTW) - (Depth to product) = LNAPL thickness

11. Decontaminate the probe and the entire length of the submerged tape in accordance with the manufacturer specifications. Refer to Attachment D for measurement equipment used at sites with known or suspected PFAS contamination and ECR SOP 010, Equipment Decontamination, for PFAS decontamination procedures.

2.4 Procedure for Measuring Total Well Depth

When measuring the total depth of a well, the water level and separate-phase product level, if present, should be determined first (see Section 2.2 or 2.3). It is recommended that the tone function of the instrument remain engaged during the total depth measurement.

1. After the water level and product level, if present, have been determined, continue reeling the electronic probe into the well riser (with the increments visible) until the probe encounters resistance. Resistance may be inferred when the probe appears to stop descending and the tape slackens against the side of the riser.

2. Determine whether the observed resistance likely represents the total depth of the well by raising and then lowering the probe to the level of the previously encountered resistance several times at different positions in the well. Then compare the observed level of resistance to available information about the total depth of the well, such as well log data or previous total depth measurements.

3. Measure the total depth of the well by: 1) noting the depth (to the nearest 0.01 feet) at which the probe first touches bottom before the tape begins to slacken; 2) adding the measured length from the bottom of the probe to the fluid level sensor in the probe; and 3) recording the combined lengths as the total depth.

4. In the field book or on the water level monitoring form, record the total depth of the well from the measuring point.

5. Also, note any observations about the conditions encountered in the well during the total depth measurement. A clear and distinct bottom reading would indicate little or no sediment in the bottom of the well. A soft and indistinct probe landing would indicate the presence of silt or sediment in the bottom of the well. A total depth measurement inconsistent with the well log or previous total depth measurements may indicate an obstruction in the well or significant sedimentation at the bottom of the well.

6. Decontaminate the probe and the portion of the tape inserted in the riser in accordance with the manufacturer specifications. Refer to Attachment D for measurement equipment used at sites with known or suspected PFAS contamination and ECR SOP 010, Equipment Decontamination, for PFAS decontamination procedures.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency.
- Check the DTW at least two times in order to compare results. If results do not agree to within 0.02 feet, take a third measurement. If results still do not agree, check for possible equipment failure or review the cautions and potential problems listed in Section 1.6. Repeat the measurement when the cause of the precision nonconformance has been discovered and corrected.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record water and separate-phase product level measurements on field forms or in a field book. See Attachment A for an example of a Water and Product Level Monitoring Form and Attachment B for an example of field book documentation.
- The following additional information may be recorded in the field book:
  - Well/piezometer or monitoring point identification number
  - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
  - Visual or sensory description (e.g., odors, product, etc.)
  - Time and date measurements were taken
  - Personnel performing the task
  - Weather conditions during task
  - Other pertinent observations
  - Measurement equipment used
  - Calibration procedures used
  - Decontamination procedures used
  - Fixed measuring point used for DTW measurements

6.0 REFERENCES

Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Manual Water Level Measurements*, SOP 2043. February 11, 2000.

U.S. EPA Region 4. Science and Ecosystem Support Division (SESD) Operating Procedure, *Groundwater Level and Well Depth Measurement*, SESDPROC-105-R2. January 29, 2013.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
1	DECEMBER 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

ATTACHMENT A

EXAMPLE WATER AND PRODUCT LEVEL MONITORING FORM

WATER AND PRODUCT LEVEL MONITORING FORM

Technician: ______________ **Job #/Task #:** ________________ **Date:** ______________

Site # ______________ **Project Manager** ________________ **Page** _____ **of** ______

Well #	TOC	Time Gauged	Total Depth (feet)	Depth to Water (feet)	Depth to Product (feet)	Product Thickness (feet)	Time Sampled	Misc. Well Notes

FIELD DATA COMPLETE QA/QC COC WELL BOX CONDITION SHEETS

MANIFEST DRUM INVENTORY TRAFFIC CONTROL

Field Mon Data Sheet GW 4/8/2013

ATTACHMENT B

EXAMPLE FIELD BOOK DOCUMENTATION FOR WATER LEVELS

Location _______________ Date 3/4/1999 109

Project / Client _______________

sunny, 80°F, slight westerly breeze

WELL I.D.	Depth To Water (ft)	Depth To Product (ft)	Measuring Point	Comments
MW-1A	2.10	–	TOC	no lock present
MW-1B	2.15	–	TOR	–
MW-2A	3.42	–	TOR	–
MW-2B	3.41	–	TOR	expansion plug missing
MW-3A	3.64	3.60	TOR	petro odor
MW-3B	3.70	–	TOC	–
MW-4A	1.55	–	TOR	–
MW-4B	1.57	–	TOR	–
MW-5A	6.30	–	TOR	–
MW-5B	6.64	–	TOR	concrete collar gone
PZ-10	4.33	–	TOR	–
PZ-11	4.22	–	TOR	–
PZ-12	4.47	–	TOR	–
PZ-13	8.03	–	TOR	–
PZ-14	8.88	–	TOR	well cap broken
PZ-15	5.09	–	TOR	–

Note: TOC = Top of casing
TOR = Top of riser

Thomas S. Weynold 3/4/99

ATTACHMENT C

SOP FACT SHEET

WATER LEVEL AND PRODUCT MEASUREMENT PROCEDURES

PURPOSE AND OBJECTIVE

The following water level and product measurement procedures have been developed to direct TRC personnel in the methods of collecting water levels and product measurements in the field. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Depth-to-water (DTW) measurements are used to evaluate pressure and/or elevation changes within the aquifer. The objective of separate-phase product measurements is to obtain measurements of the thickness of separate-phase product in the water column. Both of these measurements are very important as they drive remediation decisions.

WHAT TO USE

- Water level meter
- Oil/Water interface probe
- Extra batteries
- Well keys
- Socket set
- Decontamination supplies
- Field book
- Indelible/waterproof ink

ON-SITE WELL GAUGING

- Prior to well gauging, site water level measurement data should be reviewed for direct comparison to aid in identifying and resolving potential measurement errors while in the field.
- Conduct an operational check of the water level meter by pushing the Start or Test button on the meter to test the battery and circuitry on the water level indicator. The meter audible indicator should sound and test light illuminate.
- If possible and when applicable, start at wells that are least contaminated and proceed to those wells that are most contaminated.
- Prior to collecting a water level, record the condition of the well (e.g., protective casing, concrete collar, lock in place, etc.).
- Stand upwind of the well and remove the well lid. Unlock and remove the well cap slowly to relieve pressure buildup that may have occurred in the well casing. Allow the well time to equilibrate.
- Identify the previous measuring point marking or notch on the riser or casing (if present). If no previous measuring point exists, use a permanent marker to mark a location on the rim of the riser or casing (typically the highest point). Record this location in the field book.
- Grasp the tape with hand, withdraw the tape, and lower it slowly until the sound is audible. Check the DTW on the tape and make a mental note of the depth to within 0.01 feet. Lower the probe again slowly and repeat the measurement for precision.
- If total depth measurements were not recorded recently, advance the tape to the bottom of the well to record a total depth.
- Decontaminate the probe and tape between each well.

ON-SITE PRODUCT MONITORING

- Prior to product gauging, product measurement data should be reviewed for direct comparison to aid in identifying and resolving potential measurement errors while in the field.
- Using a previously decontaminated oil/water interface probe, turn on the meter, check the audible indicator, and slowly reel the electronic probe into the well riser (with the increments visible) until the appropriate sound for water or separate-phase product is heard (intermittent tone for water; steady tone for product).
- If water is encountered first (as determined by the audible sound on the meter, which represents water), record the DTW from the measuring point to the nearest 0.01 feet.
- If water is encountered first and dense non-aqueous phase liquid (DNAPL) is suspected, continue lowering the probe until product is encountered (as determined by the audible sound on the meter, which represents product). In the field book or on the water level monitoring form, record the depth to product from the measuring point. If light non-aqueous phase liquid (LNAPL) is encountered before water, record the depth to product from the measuring point and continue lowering the probe until water is encountered and record the depth to water.
- Decontaminate the probe and tape between each well.

WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

ATTACHMENT D

SOP MODIFICATIONS FOR PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

Water Level and Product Measurement Protocols for PFAS	
SOP Section Number	**Modifications to SOP**
1.3	• Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. • Do not use Post-it® Notes. • Use new plastic buckets for wash and rinse water. • Do not use "tap" water for operational check of the water level sensor of the oil/water interface meter. • Ensure that PFAS-free water is used during the decontamination procedure. • Do not use a plastic ruler to check measurements. • Refer to SOP 010, Equipment Decontamination, for decontamination supplies.
1.5	Always consult the Site-specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to procedures: • Tyvek® suits should not be worn. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Food and drink should not be allowed within the data measurement collection area. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with measurement data collection should wear a new pair of nitrile gloves between each well measurement. Avoid handling unnecessary items with nitrile gloves. • Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended six washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work.
2.1.1	• Do not use potable "tap" water for operational check of the water level meter. Use deionized, distilled, or organic-free water.
2.1.2 and 2.1.3	• Do not use potable "tap" water for operational check of the water level sensor of the oil/water interface meter. Use deionized, distilled, or organic-free water. • Do not use a plastic ruler to check measurements.
2.2 (7) ; 2.3 (11); and 2.4 (6)	• Use only Alconox® or Liquinox® soap; do not use Decon 90. • Ensure that PFAS-free water is used during the decontamination

Water Level and Product Measurement Protocols for PFAS	
SOP Section Number	**Modifications to SOP**
	procedure.
5.0	• Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards, and spiral bound notebooks should not be used.

Title: **Groundwater Sampling**	Procedure Number: **ECR 009**
	Revision Number: **2**
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Authorization Signatures

Cinnamon Smith	Elizabeth Denly
Technical Reviewer — Date	ECR Practice Quality Coordinator — Date
Cinnamon Smith — 11/14/16	Elizabeth Denly — 11/14/16

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
    - Passive diffusion bags (PDBs)
    - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
    - Funnel (Fill kit)
    - PVC cable ties
    - Tool to cut cable ties
    - PVC discharge tubes
    - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [μm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Drawdown	The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.
FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.
Flow-Through Cell	The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.
Flush Mount	The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a "curb box" which is an "at-grade" enclosure designed to protect the well riser.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.
Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.

Well Riser	Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.
Well Screen	Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field. Special care should be taken when sampling for PFAS. Please refer to Attachment D for details.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with RMD SOP 006, *Well Development.* The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

(1) After purging the well with the peristaltic pump, collect all fractions except VOCs from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
(2) Turn the pump off.
(3) Change into clean gloves.
(4) Disconnect the tubing coming out of the well from the inlet side of the pump and immediately put a finger over the end of this tubing to prevent water from draining out of the tubing.
(5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
(6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

Sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, if possible.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on <u>all</u> wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to ECR SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to ECR SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see RMD SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in SOP 004 *Water Level and Product Measurements*.

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = πr^2 h (cf) **Equation 1**

where:

π = pi (3.14)

r = radius of well in feet (ft)

h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]

cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:

h = height of water column (feet)

f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25' to 30') and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110-

or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

<u>Dedicated systems:</u> Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

<u>Non-dedicated systems:</u> Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\,(mL / min) = \frac{volume\ collected\ (mL)}{1\,minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

<u>Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH):</u> Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample
- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

Interstate Technology Regulatory Council (ITRC). March 2006. *Technology Overview of Passive Sampler Technologies.*

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA Ground Water Issue. EPA/540-S-95-504. USEPA Office of Solid Waste and Emergency Response.

USEPA. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. EPA/542-S-02-001. USEPA Office of Solid Waste and Emergency Response.

USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling.* SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples.
http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2014	NOT APPLICABLE
1	JULY 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFCS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.
2	NOVEMBER 2016	ADDED ADDITIONAL INFORMATION REGARDING PFAS.

Attachment A:

Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

Jurisdiction	Information Source	Applicable Stabilization Criteria
USEPA Region 1	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; U.S. Environmental Protection Agency Region 1, January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf (for low flow PDF) http://www.epa.gov/region1/lab/qa/qualsys.html (for EPA's Quality System Documents)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% if >5 NTUs; if three Turbidity values are <5 NTU, consider the values as stabilized Dissolved Oxygen: ±10% if >0.5 mg/L, if three Dissolved Oxygen values are <0.5 mg/L, consider the values as stabilized Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 2	Groundwater Sampling Procedure: Low Stress (Low Flow) Purging and Sampling, SOP # SST-7, Revision No. 1, November 2010.	Same as above
USEPA Region 4	USEPA Region 4 SOPs: http://www.epa.gov/region4/sesd/fbqstp/index.html See Chemical Parameter Stabilization Criteria (section 3.2.1.1.2 of Groundwater Sampling SOP, revision 3/6/2013: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf	pH: ±0.1 unit Specific Conductance: ±5% Temperature: Not used Turbidity: "Stabilized" (no criteria specified) if >10 NTUs ; if three Turbidity values are <10 NTUs, consider the values as stabilized Dissolved Oxygen (optional parameter): ±0.2 mg/L or ±10% of saturation, whichever is greater Oxidation/Reduction Potential: Not used
USEPA Region 5	Ground Water Forum Issue Paper (May 2002, Yeskis and Zavala) http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf A minimum set of parameters would include pH, conductivity, and turbidity or DO. Puls and Barcelona, 1996 (pH, specific conductance, ORP, turbidity) Wilde et al., 1998 (pH, turbidity, DO)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: Not used Turbidity: ±10% if >10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 9	See USEPA Region 1 (above)	
USEPA Region 10	See USEPA Region 5 (above)	
Alabama	Alabama Environmental Investigation and Remediation Guidance (section C.3.1) http://www.adem.state.al.us/MoreInfo/pubs/AEIRGInvestigation.pdf	pH: ±0.1 unit Specific Conductance: ±10% Temperature: "Constant" (no criteria specified) Turbidity: Stabilized (no criteria specified), or <10 NTUs Dissolved Oxygen: No criteria specified Oxidation/Reduction Potential: No criteria specified

Jurisdiction	Information Source	Applicable Stabilization Criteria
Indiana	Indiana Department of Environmental Management The Micro-Purge Sampling Option http://www.in.gov/idem/files/remediation_tech_guidance_micro-purge.pdf The parameters normally measured for stability (listed in increasing order of sensitivity) are pH, temperature, specific conductivity, oxidation-reduction potential, DO and turbidity. At least one of the last three listed must be used.	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% Dissolved Oxygen: ±10% Oxidation/Reduction Potential: ±10 millivolts (document says microvolts, but that may be an error)
Michigan	MDEQ Part 201 Op Memo 2, Attachment 5 http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_2_Attachment5_249853_7.pdf	No specific values to determine stabilization are listed, but the Op Memo lists several other groundwater sampling guidance documents. If a valid reference exists, then it can be used to justify a sampling approach and stabilization parameters.
New Jersey	New Jersey Department of Environmental Protection http://www.state.nj.us/dep/srp/guidance/fspm/	pH: ± 0.1 unit Specific Conductance: ± 3% Temperature: ± 3% Dissolved Oxygen: ± 10% Turbidity: ± 10% for values greater than 1 NTU ORP/Eh: ± 10 millivolts
Ohio	Ohio EPA SOPs: http://www.epa.state.oh.us/portals/30/rules/FSOPs.pdf See Purging Stabilization Criteria (SOP 2.2.4, dated January 2, 2007, review in progress)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: No criteria specified Turbidity: Below 10 NTUs ideal; ±10% if greater than 10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
This table was last updated in July 2014.		

Attachment B:

Example Groundwater Field Data Records

TRC

Groundwater Field Data Record

Project: Project No.: Date/Time: Sheet ___ of ___

TRC Personnel: Well ID:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure		
Concrete Collar Intact		
PVC Stick-up Intact		
Well Cap Present		
Security Lock Present		

Sampling Equipment:

Flow-thru Cell Volume:

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) _______ ft.

Riser Stick-up (from ground) _________ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch
Other: ________

WELL MATERIAL
☐ PVC ☐ SS
Other: ______

Well Depth ______ ft. ☐ top of riser ☐ top of casing ☐ __________ ☐ measured ☐ historical

Water Depth ______ ft. LNAPL/DNAPL Depth = _____
Well Volume ______ NAPL Thickness = ______

Depth of pump intake:
Static water level after pump put into well:

Initial purge Rate/ Water Level (100-400 ml/min):

Adjusted purge Rates/time/WL(record changes)

Flow rate at time of sampling:

Total volume of water purged:

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

Time									
Temp. (°C)									
Conduct. (µmhos/cm)									
DO (mg/L)									
pH (su)									
ORP (millivolts)									
Turbidity (NTU)									
Flow (ml/min)									
Depth To Water (ft)									
Cumulative Purge Vol. (gal or L)									

Time						
Temp. (°C)						
Conduct. (µmhos/cm)						
DO (mg/L)						
pH (Std. Units)						
Eh/ORP (millivolts)						
Turbidity (NTU)						
Flow (ml/min)						
Depth To Water (ft)						
Cumulative Purge Vol. (gal or L)						

Stabilization Criteria*
(3 consecutive readings)
- Temperature: ± 3 %
- Conduct. (µmhos/cm): ± 3 %
- DO (mg/L): ± 10 % (for values >0.5 mg/L)
- pH (Std. Units): ± 0.1 SU
- ORP (millivolts): ± 10 mV
- Turbidity (NTU): +/- 10 % (for values >5.0 NTUs)
- Drawdown: < 0.3 ft (can be greater as long as water level stabilizes above well screen)

	Purge	Sample
Peristaltic Pump		
Submersible Pump		
Bladder Pump		
Bailer		
Other: ________		

Comments:

Analytical Parameter	Filtered (Y/N)	Preservation	# Bottles	Size/Type Bottles	Time Collected	QC	Sample #

* Consult the applicable regulatory guidance for the specific criteria.

Signed: ______________________

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WATER SAMPLE LOG

PROJECT NAME:		PREPARED		CHECKED	
PROJECT NUMBER:		BY:	DATE:	BY:	DATE:

SAMPLE ID: WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6" ☐ OTHER ________

WELL MATERIAL: ☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER ________

SAMPLE TYPE: ☑ GW ☐ WW ☐ SW ☐ DI ☐ LEACHATE ☐ OTHER ________

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:

PURGE METHOD: ☐ PUMP ________ ☐ BAILER ________

DEPTH TO WATER: ________ T/ PVC

DEPTH TO BOTTOM: ________ T/ PVC

PUMP INTAKE DEPTH: ________ T/ PVC

FLOW-THRU CELL VOLUME ________ LITERS

WELL VOLUME: ________ ☐ LITERS ☐ GALLONS

VOLUME REMOVED: ________ ☐ LITERS ☐ GALLONS

COLOR: ________ ODOR: ________

TURBIDITY

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY

DISPOSAL METHOD: ☐ GROUND ☐ DRUM ☐ OTHER

PH: ________ SU CONDUCTIVITY: ________ umhos/cm

ORP: ________ mV DO: ________ mg/L

TURBIDITY: ________ NTU

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY

TEMPERATURE: ________ °C OTHER: ________

COLOR: ________ ODOR: ________

FILTRATE (0.45 um) ☐ YES ☐ NO

FILTRATE COLOR: ________ FILTRATE ODOR: ________

QC SAMPLE: ☐ MS/MSD ☐ DUP- ________

COMMENTS:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - ________

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD: ________ DATE SHIPPED: ________ AIRBILL NUMBER: ________

COC NUMBER: ________ SIGNATURE: ________ DATE SIGNED: ________

Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)

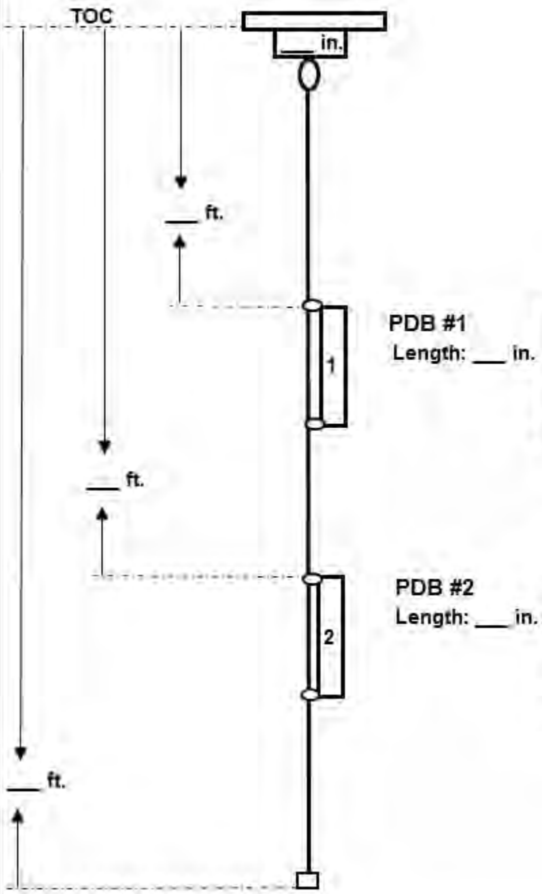
Project Name/No:	Well ID:

Installation of PDBs:

TRC Personnel: ______
Date: ______
Time: ______
DTW (ft): ______

Sampling of PDBs:

TRC Personnel: ______
Date: ______
DTW (ft): ______



PDB #1

Sample ID: ______
Sample Time: ______
Evidence of algae, iron or other coatings?: ______

PDB #2

Sample ID: ______
Sample Time: ______
Evidence of algae, iron or other coatings?: ______

Measured well depth during tether installation: ___ ft.

Field Notes:

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Attachment C: SOP Fact Sheet

GROUNDWATER SAMPLING

PURPOSE AND OBJECTIVE

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling. All three approaches are summarized in this document.

WHAT TO BRING

- Site-specific HASP and field book
- Project-specific work plan
- Figure or site map showing well locations and table showing well construction details
- Field data sheets from previous sampling event
- Well wrenches, ratchet set, and turkey baster to remove standing water from flushmount manholes
- Bolt cutters, padlocks and keys
- Water level meter of sufficient length
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing (Teflon®, Teflon®-lined polyethylene, or HDPE, type dependent upon project objectives)
- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, ORP, and DO)
- Turbidity meter
- Equipment decontamination supplies (refer to RMD SOP 010, *Equipment Decontamination*)
- Appropriate PPE
- Field book
- Sample bottleware, labeled cooler, ice, temperature blank and blank COC forms; may also need field blank bottles and reagent-grade water
- Zip-loc® plastic bags
- Groundwater field data records
- Graduated cylinder and stop-watch
- Rope for tying off pump at desired intake
- Indelible marking pens
- Bubble wrap
- 5-gallon bucket(s)

As Needed:

- Calibrated PID or FID for well mouth readings
- Oil/water interface probe of sufficient length
- Drums for purge water, grease pen and adhesive drum labels; appropriate crescent or socket wrench
- Filtration equipment, if required (0.45 micron filters, or as otherwise required for the project)
- Other non-routine PPE such as Tyvek coveralls or respirators
- Traffic cones
- Field calibration sheets and calibration solutions

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the most recent version.
- Review the project-specific work plan with the Project Manager and/or the field team leader. Discuss the following:
  - Communication procedures;
  - Sampling order and designation;
  - Collection and sample method;
  - Analytical parameters, holding times and turn-around times;
  - Laboratory (contact/shipping info, COC, billing references);
  - Purge water management (Drums? Discharge to ground?);
  - QC sample collection; and
  - Decontamination procedures.
- Verify that monitoring wells will be accessible and/or coordinate to have a site contact available to assist.
- Make sure that monitoring well sample designations and QC sample designations/frequency are understood.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure or mobilization to site, test equipment and make sure it is in proper working order. Have rental equipment supplier contact information available for use in field.
- Review sample bottle order for accuracy and completeness and damaged bottles.
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager

ON-SITE

GROUNDWATER SAMPLING

- Review the HASP with all field personnel, sign acknowledgement form and conduct Health & Safety tailgate meeting. Check in security, site contact, or designated person per project-specific work plan or Project Manager.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.
- Open wells to allow equilibration and collect full round of water level gauging before sampling is started (unless otherwise noted in project-specific work plan). Record the following:
  - Well mouth PID/FID reading (if necessary);
  - Depth to product and water;
  - Total well depth (not required if free product is measured unless otherwise noted in project-specific work plan); and
  - Condition of wells (i.e., lid broken, pad cracked, rusted lock) and collect photographs if site allows camera use.

SAMPLING PROCEDURES: PRE-PURGE

- Decontaminate pump.
- Take water level measurements prior to pump installation.
- Connect sampling tubing to pump outlet and lower to sample depth; **ALWAYS USE ROPE TO SECURE PUMP TO SURFACE.**
- The pump intake depth(s) for each well should be specified in the project-specific work plan (either specific depth or mid-point of saturated well screen).
- For wells with screened or open borehole intervals greater than 10 feet in length, sampling of multiple intervals may be required.
- If samples are to be collected from multiple depths from an individual well, always collect a sample from the shallowest depth first and leave enough extra tubing coiled at the surface so the pump can be lowered to the next interval; always try to cover excess tubing present at the surface to prevent the air temperature from influencing the measurements and exposure to contaminants on the ground;
- Be careful not to let the pump hit the bottom of the well.
- If using Teflon®-lined tubing, be sure that the lining does not bunch up around the connection. This will restrict water flow and make the pump work harder than it has to.
- Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

SAMPLING PROCEDURES: MULTIPLE-VOLUME PURGING

- The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization.
- The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters.
- Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. Once this information is known, the well volume can be calculated using the following equation:

  Well Volume (V) = $\pi r2$ h
- For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed.
- For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.
- If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume.
- In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection.
- If, after 3 well volumes have been removed, the field parameters have not stabilized, additional well volumes (up to a total of 5 well volumes), should be removed.
- If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging.

SAMPLING PROCEDURES: LOW-FLOW PURGING

- The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample.
- When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval to help prevent disturbance of any sediment at the bottom of the well.

GROUNDWATER SAMPLING

- To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.
- The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings.
- Attempts should be made to avoid pumping a well dry.

Field Parameter Stabilization During Purging

- Generally, an adequate purge with respect to the groundwater chemistry is achieved when stability for at least three consecutive measurements is achieved. See stability requirements in Appendix A of this SOP.

POST-PURGE GROUNDWATER SAMPLE COLLECTION

- New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.
- If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.
- If using bottom-filling bailers, slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling). Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.
- Collect groundwater samples in the following order:
  - VOCs;
  - SVOCs;
  - Other organic parameters;
  - Unfiltered inorganic constituents; and
  - Filtered inorganic constituents.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Preserve the non-VOC samples in pre-preserved vials supplied by the laboratory or if the sample containers are not pre-preserved, preserve the non-VOC samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed. See procedures listed in Section 2.3.4 of this SOP. Clearly note "filtered" on the sample label and the COC.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment between uses.

PASSIVE SAMPLING

- There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers. Be aware of sample holding times, and arrange for samples to be in the laboratory's possession accordingly.
- Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.
- New passive samplers are attached via PVC cable ties to a tether (pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well.
- The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers).
- Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.
- Detach the passive sampler from the tether.
- Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

GROUNDWATER SAMPLING

- Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. The VOA vials must be filled within the first several minutes of passive sampler retrieval.
- A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.
- Dispose of the passive sampler after use.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.

DOs AND DO NOTs OF GROUNDWATER PURGING AND SAMPLING

DOs:

- DO have the following items when going into the field: site-specific work plan; site-Specific HASP; appropriate PPE (steel-toed boots, safety glasses, etc.) as required by the Site-Specific HASP; field book and a water-proof ball-point pen; business cards; nitrile gloves; well keys; copies of well installation forms and field data forms from previous sampling event.
- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled. There is little time between taking parameters.
- DO look at the water quality parameters from the previous round of sampling. If there is a large deviation from the previous round's measurements, make sure the meters are properly calibrated and the parameter units are the same. Otherwise, consult the Project Manager or field team leader.
- DO fill sample bottles slowly to make sure that they are not overfilled and that preservative does not become diluted. If collecting filtered samples, fill all non-filtered first, then fill filtered samples - if water is very silty, more than one filter might be required to fill sample bottles.
- DO record the time that purging begins and ends. "Purge Stop" and sample start time are the same.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them. It is also recommended to call when sampling is winding down for the day to make sure that the project-specific work plan has been fully implemented and there are no additional tasks to complete. Provide shipping tracking numbers to the Project Manager and laboratory contact.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO record sample locations and parameters in the field book and the Groundwater Field Data Records as you purge.
- DO check on the purging setup frequently to make sure proper equipment function is maintained.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if this is an issue.
- DO NOT allow the pump or sampling equipment to hit the bottom of the well - If the pump hits the bottom of the well, it can stir up mud. Remember, the goal of low-flow sampling is to collect non-turbid samples.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT leave air bubbles in VOA vials.
- DO NOT pour any extracted water back down into the well.
- DO NOT lean over wells with pens, keys, cell phones, tools, etc. in your pocket.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

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Attachment D: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing. • Passive diffusion bags (PDBs) should not be used due to the presence of LDPE material in PDBs. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use LDPE or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil. • Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. • Do not use Post-It Notes during sample handling or mobilization/demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with sample collection and handling should wear

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
	nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up to sample a well.
1.6.1	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
2.2.5	Tubing used to purge and sample groundwater for PFAS must not be LDPE or Teflon®. HDPE and silicone are acceptable.
2.3 and 2.3.3	LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable.
2.4	Due to LDPE material in PDBs, PDBs cannot be used for PFAS sampling.
2.5 (e)	Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable.
2.5 (f)	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable.
4.3	Due to low reporting limit requirements for PFAS, trip blanks for PFAS analysis should be included in sample coolers if PFAS are being analyzed for in the associated groundwater samples.

Notes:

[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

Title: **Residential Well Sampling**	Procedure Number: **ECR 016**
	Revision Number: **1**
	Effective Date: **November 2016**

Authorization Signatures	
Technical Reviewer — Date Richard Gille — 11/14/16	ECR Practice Quality Coordinator — Date Elizabeth Denly — 11/14/16

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ATTACHMENTS

Attachment A	Residential Well Sampling Log
Attachment B	Quick Reference Sheet
Attachment C	SOP Modifications for PFAS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the sampling of residential drinking water wells. This SOP details equipment and sampling procedures for the collection of drinking water samples from residential drinking water well systems.

The objective of drinking water sampling is to obtain a representative sample of fresh water from the drinking water well that has been recently recharged with local groundwater. This requires that the stagnant water in the well or plumbing system be purged prior to sampling, particularly if the well has not been used for several hours or longer.

1.2 Summary of Method

In order to obtain a representative drinking water sample for analysis, it is important to purge the stagnant water in the plumbing and/or well before collection of the sample and to collect the sample at an appropriate system location that may be upstream of any existing treatment system or after removal of aerators from sample points to limit potential loss of volatile compounds or oxidation of metals during sampling.

If the well has been used within the last 24 hours, the sampling point should be allowed to run at a moderate flow for enough time to allow at least one system expansion tank volume to be purged. In the event that the well has not been used for a period of 24 hours or longer, the system should be purged until three expansion tank volumes of water have been removed. For projects that require field parameters to be collected, a connection to the sampling point should be created to eliminate exposure to air.

For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment C for further details. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following list of equipment may be utilized when sampling a residential well system. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Graduated measuring container (for purge rate)
- Garden hose or polyvinyl chloride (PVC) tubing (to divert purge water, if necessary)
- Sample cooler(s)
- Ice

- Chain-of-custody (COC) forms
- Sample bottle labels
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Residential Well Sampling Log
- Homeowner contact information
- Tape measure
- Isopropyl alcohol (when sampling for bacteria)
- Filtration equipment
- In-line filter (0.45 micron [µm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Stopwatch or timer
- Camera
- Wrenches, pliers
- 5-gallon buckets with lids

If Collecting Field Parameters:

- Polyethylene tubing: 1/4 inch or 3/8 inch inner diameter (preferred)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Turbidity meter (as applicable – consult project-specific work plan)
- Site-specific device for connection to the sample point
- Tubing cutter
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open

1.4 Definitions

Expansion Tank	A holding tank containing a rubber bladder that is under pressure and is used to store and distribute water through the plumbing system; typically found close to the point where the supply line from the well enters a home; usually blue in color and generally has a 10 to 40-gallon capacity.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

When entering a residential home, a line of communication should be maintained between the field staff and the Project Manager. Notification should be made to the Project Manager when entering each residential home and upon exiting the home. When possible, a team of two should perform residential sampling when entering a home is required.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field. Special care should be taken when sampling for PFAS. Please refer to Attachment C for details.

1.6.1 Pre-Sampling Issues

(a) Access with homeowners should be scheduled in advance. It will be helpful to have homeowner contact information in the field in the event that the homeowner is not home for the appointment.

(b) If an appointment cannot be coordinated with the homeowner, permission may be granted by the homeowner for TRC to collect the sample from an exterior hose faucet when the homeowner is not present. Information regarding any pre-treatment systems prior to the outside faucet should be obtained in advance from the homeowner. If possible, arrangements should be made with the homeowner to bypass the treatment system on the day of sample collection. Note that if a hose is connected to the outdoor faucet, it should be removed before collecting the sample and dirt or detritus should be removed from the faucet to prevent foreign matter from inadvertently being entrained in the samples. Inquire about any recent plumbing work.

(c) The size of the expansion tank should be obtained from the homeowner to calculate the volume of water to be purged prior to sampling. It is also beneficial to obtain the make and model of the expansion tank (e.g., Well-X-Trol WX-202D) as the specifications, including volume, can usually be obtained from the manufacturer's website.

1.6.2 General Purging and Sampling Issues

(a) Where possible, samples should be collected from a bypass point upstream of the expansion tank and any working treatment systems. If there is no bypass point, water may be collected from a kitchen or bathroom faucet after aerators, if present, have been removed.

Note that when sampling for bacteria, the spigot should be disinfected with isopropyl alcohol <u>prior</u> to purging to avoid potential false positives. As an alternative to isopropyl alcohol, the following procedure recommended by the Wisconsin State Laboratory of Hygiene could be used for disinfection:

- Use a flame to disinfect the end of metal faucets for bacteria testing. A propane torch or butane lighter can be used to heat the end of the faucet until hot.
- Turn on the water and allow the water to run for five minutes or until you hear the pump turn on before you collect a bacteria sample.

It should be noted that this method should not be used on chrome or plastic faucets or faucets with plastic internal parts.

Samples for volatile organic compounds (VOCs) should be collected prior to disinfection to avoid the potential for entrainment of isopropyl alcohol in the volatile organic analyte (VOA) vial which could cause interference with the VOC analysis.

If sampling is being conducted before and after a treatment system to determine its effectiveness, then the "after" point should be sampled first.

(b) Typically, interior faucets are equipped with aerators; if possible this aerator should be removed prior to purging and sampling. If removal of the aerator is not possible, this must be noted in the field book or on the Residential Well Sampling Log (Attachment A). It should be noted that aerators may be contaminated with bacteria if not routinely cleaned or replaced when worn or cracked.

(c) Procedures should be established to minimize cross-contamination. For example, always sample directly from the sample point (not through tubing used to monitor field parameters from multiple sample points).

(d) Ensure monitoring instruments (e.g., multi-parameter water quality instrument, turbidity meter) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(e) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL VOA vials for VOC analysis) due to potential interference with analytical equipment.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the project-specific work plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field book.

2.1 Pre-Sampling Activities

(a) Create a schedule of appointments with homeowners ahead of time. Notification of a minimum of three (3) days prior to sampling is preferred, but in some cases, this advance notice may not be possible. Be sure to allow for adequate time between appointments for sampling and to account for potential slow purging of the well. The following information should be tabulated ahead of the sampling event for each well to be sampled: name(s) of the resident(s) or water supply owner/operator, exact physical address, exact mailing address (if different from the physical address), resident's/operator's home, work and mobile telephone numbers (when available).

(b) Request that the homeowner have information on the location, age, yield, and construction of their well; size of expansion tank; and type of treatment system (if any) available at the time of the appointment. If the homeowner does not have information pertaining to the expansion tank, look on the tank for the manufacturer's name and model number; this information is often helpful in identifying the volume of the expansion tank.

(c) Obtain available information for water supply wells to be sampled including well construction details, the date of installation, and any available water quality data for the well.

(d) Calibrate (or perform a calibration check) on all field monitoring equipment on the same day before collecting well system samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day; consult the project-specific work plan.

(e) Record the sample location, time, and date in the field book and/or on the Residential Well Sampling Log (Attachment A). Also record the information regarding the well system listed in (b) above.

(f) Identify the best location for sampling, preferably the location nearest the well (e.g., bypass point, prior to any treatment systems, or faucets). If sampling both before and after a treatment system, sample the "after" point first.

(g) If using an exterior spigot for sampling, hoses need to be removed and the spigot should be cleaned of debris prior to sampling so that soil or detritus or other potential sources of extraneous contamination are not inadvertently entrained in the sample.

2.2 *Purging Activities*

Prior to sampling residential wells, the plumbing system must be purged to facilitate collection of a representative sample. Most household expansion tanks have a capacity of between 10 to 40 gallons. The goal of purging is to introduce representative fresh water into the system prior to sampling. If the well is known to have recently (i.e., less than 24-hours) been in use, only one volume of the expansion tank needs to be purged. The capacity of the expansion tank is typically identified on a tag on the expansion tank. If this tag is missing, the volume (in gallons [gal]) can be estimated as the square of the radius of the expansion tank (in feet [ft]) multiplied by the height of the tank (ft) times a factor of 23.5.

$$Tank\ Volume\ (gal) = Tank\ Radius\ (ft)^2 \times Tank\ Height(ft) \times \frac{7.48\ gal}{1\ ft^3} \times \pi$$

If the well is not known to have been used during the past 24 hours, a greater volume will need to be purged. It is recommended that in this instance, the system be purged until an equivalent of three expansion tank volumes are removed. Note that most household taps deliver 2 to 3 gallons per minute (gpm) while outside taps can deliver up to 5 gpm. All purging should be performed using the cold water tap.

2.2.1 Purging With No Field Parameters

(a) Remove aerator if present and begin purging the sampling point either into 5-gallon buckets or down the drain if at a faucet.
(b) When sufficient volume has been purged from the well as described above, the sample can be collected.
(c) Record the quantity of water purged and the length of purging time in the field book or on the Residential Well Sampling Log (Attachment A).

2.2.2 Purging While Collecting Field Parameters

(a) Purge water from the purge point per Section 2.2 and then shut down the purge point.
(b) Connect polyethylene tubing to the purge point. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Because purge points will vary in type, the homeowner should be asked about the purge point in advance so the appropriate tubing/connection equipment is brought for the appointment.
(c) Connect the polyethylene tubing to the flow-through cell with the water quality parameter instrument already inserted into it. Direct the discharge line from the flow-through cell to a 5-gallon bucket to contain the purge water for subsequent disposal, or directly into the sink (as applicable). **Note that when field parameters do not include DO and/or ORP, Steps (b) and (c) are not required and parameters can be measured in an open container.**
(d) Measure the flow rate (in liters per minute [L/min]) with a graduated container (in milliliters [mL]) and stop watch. Record the volume of water collected for a period of one minute and calculate the flow rate as follows.

$$Flow\ rate\ (L\ /\ min) = \frac{volume\ collected\ (mL)}{1\ minute}\ x\ \frac{1\ L}{1000\ mL}$$

(e) Adjust the flow rate to approximately 3.8 L/min (1 gpm) or less. Make sure that the flow rate is sufficiently low so as to not aerate the sample.
(f) Begin monitoring field parameters at approximately 3 to 5 minute intervals.
(g) Continue monitoring until three consecutive measurements of field parameters have stabilized. Stabilization criteria may depend on project objectives or regulatory-specific requirements. Generally, an adequate purge with respect to the water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered stable.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

(h) Record measurements in accordance with Section 5.0 on the Residential Well Sampling Log (Attachment A).
(i) Record the quantity of water purged and the length of purging time in the field book or on the Residential Well Sampling Log (Attachment A).

2.3 Sample Collection

(a) After the appropriate purge volume has been removed and after field parameters have stabilized (when applicable) per Section 2.2.2(g), samples may be collected.
(b) Adjust the flow rate to approximately 0.4 L/min (0.1 gpm).
(c) Samples should be collected directly from the sample point; if connected, remove tubing from faucet prior to sample collection.
(d) Fractions of the drinking water sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals);
6. Bacteria; and
7. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

(e) <u>Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH):</u> Samples for VOCs/VPH will be collected first and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Confirm that no air bubbles have formed during capping by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

When acid preservation is used for the collection of VOCs/VPH, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

(f) Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.1 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. Re-attach the discharge tubing. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of well water from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document and in the field book and/or Residential Well Sampling Log (Attachment A).

2.4 Post-Sampling Activities

(a) Cease purging and disassemble and decontaminate reusable purging and sampling equipment.
(b) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.
(c) Place all samples in a cooler with ice.
(d) Ensure samples are delivered to the laboratory well before the required holding time expires.
(e) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste (IDW) disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of quality control (QC) samples is dependent upon the project-specific requirements. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of residential well water samples:

(a) For QC purposes, each duplicate sample will typically be submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for residential well water sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Residential Well Sampling Log (Attachment A).

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, filtered inorganic constituents, bacteria, and other constituents), the duplicate sample containers will be alternately filled with residential well water for each parameter.

(c) All collection and preservation procedures outlined for residential well water sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through non-dedicated sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. In general, equipment blanks will not be required with residential well sampling since samples are typically collected directly from the sample point.

If equipment blanks are required, the reagent water should ideally come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or

VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 MS/MSDs and MS/Duplicates

Matrix spikes (MSs) are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. Matrix spike duplicates (MSDs) are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the comments column of the COC document and in the field book.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book or on the Residential Well Sampling Log (Attachment A). This log should be used to record the following:

- Volume of each sample
- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as pH, temperature, conductivity, turbidity, ORP, and DO
- Well construction information (if available) including depth, diameter and yield of well, type of well (drilled or dug) and information regarding water treatment (as applicable)
- Indication of whether the well has been pumped during the 24-hour period prior to sampling
- Expansion tank capacity

- Decontamination procedures
- Analytical parameters
- Preservation methods

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

California Department of Pesticide Regulation. July 2011. *Standard Operating Procedure, Obtaining and Preserving Well Water Samples,* SOP No. FSWA001.02. California Department of Pesticide Regulation Environmental Monitoring Branch.

USEPA. May 28, 2013. *Potable Water Supply Sampling*. SOP No. SESDPRC-305-R3. USEPA Region 4 Science and Ecosystem Support Division.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2015	NOT APPLICABLE
1	NOVEMBER 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

Attachment A

Residential Well Sampling Log

Residential Well Sampling Log	**Project:**	**Project Number:**
	Address of Residence:	**Sample ID:**
	Homeowner's Name:	**Date:**
	Contact Number:	**Sample Time:**
		Sampler's Name:

Description of Sample Location *(circle one)* :

System Bypass Exterior Faucet Kitchen/Bath Faucet

Sketch of Sample Location	**Expansion Tank and Upstream Pipe Capacity**
	Tank Capacity (gallons) = ________
	Tank Capacity (gallons) - if not stamped on tank = (radius of tank [ft]^2*height of tank [ft])* 23.5
	Pipe Capacity (gallons) = ________
	Pipe Capacity (gallons) = (radius of pipe [ft]^2* length of pipe upstream of tank [ft])* 23.5

Required Purge Volume: __________ (gallons)	**Well Used in Past 24 Hours? *(circle one)***
Actual Purge Volume Prior to Sampling: _______(gallons)	Yes No Unknown
Purge Time Duration: ________ (min)	Faucet Aerator present? Yes No
Flow Rate During Sampling: ____________ (gpm)	Faucet Aerator removed prior to sampling? Yes No

Field Parameters (If Applicable)

Time										
Temp (°C)										
Conduct. (umhos/cm)										
DO (mg/L)										
pH (std units)										
ORP (millivolts)										
Turbidity (NTU)										
Volume purged (gal)										
Flow Rate (ml/min)										

Laboratory Analysis

Analytical Parameter	**Filtered? Y N**	**Preservation**	**pH Chk**	**Volume**	**# of Bottles**

Notes: (age, type [drilled/dug], well depth, well yield, water treatment system type, where applicable)

QC Sample (Field Duplicate or MS/MSD) Collected?

July 2015

Attachment B

Quick Reference Sheet

RESIDENTIAL WELL SAMPLING

PURPOSE AND OBJECTIVE

The objective of drinking water sampling is to obtain a representative sample of fresh water from a drinking water well that has been recently recharged with local groundwater. This requires that the stagnant water in the well and/or plumbing system be purged prior to sampling, particularly if the well has not been used for several hours or longer.

WHAT TO BRING

- Site-specific HASP
- Project-specific work plan
- Field book
- Residential Well Sampling Log forms
- Homeowner contact information
- Garden hose or PVC tubing
- Tubing (type dependent upon project objectives)
- Pliers, wrenches
- Tape measure
- Equipment decontamination supplies
- Appropriate PPE
- Sample containers, labels, cooler, ice, blank COC forms
- Stopwatch or timer
- Zip-loc® plastic bags
- Graduated cylinder
- Indelible marking pens
- 5-gallon bucket(s)
- Camera
- Lint-free, non-abrasive, disposable towels

As Needed:

- Multi-parameter instrument and flow-through cell (typically includes: pH, temperature, conductivity)
- Isopropyl Alcohol (when sampling for bacteria)
- Filtration equipment, if required (0.45 micron filters, or as otherwise required for the project)
- Instrument calibration instructions and solutions

OFFICE

- Prepare/update/review the site-specific HASP.
- Review the project-specific work plan with the Project Manager and/or the field team leader.
- Set up appointments with homeowners in advance of the sampling and discuss with them the general procedures that will be followed and verify sample points are accessible.
- Interview the homeowner to obtain information regarding treatment systems, well depth and pressure tank size for the well system.
- Make sure that well sample designations and QC sample designations/frequency are understood.
- Confirm that all necessary equipment is available in-house or has been ordered. Review sample bottle order for accuracy and completeness and damaged bottles.
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

PRE-PURGE AND SAMPLING ACTIVITIES

- Create a schedule of appointments with homeowners ahead of the sampling effort. Allow for adequate time between appointments for sampling and to account for potential slow purging of the well.
- Interview the homeowner to obtain information on the location, age, yield, and construction of their well; size of expansion tank; and type of treatment system (if any).
- Obtain available information for water supply wells to be sampled including well construction details, the date of installation, and any available water quality data for the well.
- If possible, inspect the potable water system components to obtain information on expansion tank size (look for make, model and/or stated volume), tap locations, and the presence or absence of treatment systems. Take note of any well details present in the vicinity of the expansion tank/water system (sometimes posted on the expansion tank if well pump replaced recently).
- Record all potable water well system details on the Residential Well Sampling Log form or in a field book.
- Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting well system samples. Refer to requirements in TRC SOPs, project-specific work plan, and manufacturer's equipment calibration instructions. Identify tap locations for sampling, preferably the location nearest the well. If sampling before and after treatment systems, be sure to sample the post treatment tap first.
- If purging and sampling from a faucet, remove the aerator from the faucet prior to purging and sampling.
- If purging and sampling from an exterior spigot, ensure than any dirt and/or debris is cleaned from the spigot.

PURGING ACTIVITIES

- Calculate the volume required to purge one expansion tank volume (if the well has been in use in the last 24 hours). If the well is not known to have been used within the last 24 hours, 3 expansion tank volumes should be purged prior to sampling.
- If the exact expansion tank volume is not known, it can be estimated using the equation in the SOP.

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RESIDENTIAL WELL SAMPLING

- Note that most household taps and spigots deliver approximately 2 to3 gallons per minute (GPM).
- All purging and sampling should be performed using the cold water tap.

PURGING WITH NO FIELD PARAMETERS

- Remove faucet aerator if present and begin purging the sampling point either into 5-gallon buckets or down a drain.
- When a sufficient volume has been purged from the well as described above, the sample can be collected. If a hose was used to direct the purge water, remove it prior to sampling.
- Record the quantity of water purged and the length of purging time in field book or on the Residential Well Sampling Log form.

PURGING WHILE COLLECTING FIELD PARAMETERS

- Connect polyethylene tubing to the purge point.
- Connect the polyethylene tubing to the flow-through cell with the water quality parameter instrument inserted into it. Direct the discharge line from the flow-through cell to a 5-gallon bucket to contain the purge water for subsequent disposal, or directly into a drain (as applicable). Note that when field parameters do not include DO and/or ORP, no tubing connections are necessary and parameters can be measured in an open container.
- Measure the flow rate (in liters per minute [L/min]) with a graduated container (in milliliters [mL]) and stop watch. Record the volume of water collected for a period of one minute and calculate the flow rate using the equation in the SOP.
- Adjust the flow rate to approximately 3.8 L/min (1 gpm) or less so the flow rate is low so as to not aerate the sample.
- Begin monitoring field parameters at approximately 3 to 5 minute intervals.
- Continue monitoring until three consecutive measurements of field parameters have stabilized. Stabilization criteria may depend on project objectives or regulatory-specific requirements. Generally, an adequate purge with respect to the groundwater chemistry is achieved when stability for at least three consecutive measurements is as indicated in the SOP.
- Record field parameter measurements, total volume of water purged and the length of the purging time on the Residential Well Sampling Log form or in the field book.

SAMPLE COLLECTION

- New, disposable gloves should be donned immediately prior to sample collection and when their cleanliness becomes compromised.
- Adjust the flow rate to approximately 0.4 L/min (0.1 gpm).
- Samples should be collected directly from the sample point; if connected, remove tubing from faucet prior to sample collection.
- Fractions of the drinking water sample should be collected in the appropriate order (i.e., decreasing volatility) per the SOP unless otherwise specified in the project-specific work plan.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial and no air bubbles are present.
- Appropriately preserve the samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed for non-VOC analyses. See filtering procedures listed in Section 2.3.1 of this SOP.
- Decontaminate non-disposable sampling equipment between uses.

DOS AND DO NOTS OF RESIDENTIAL WELL SAMPLING

DOs:

- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled. There is little time between taking parameters.
- DO look at the water quality parameters from the previous round of sampling. If there is a large deviation from the previous round's measurements, make sure the meters are properly calibrated and the parameter units are the same.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them. It is also recommended to call when sampling is winding down for the day to make sure that the project-specific work plan has been fully implemented and there are no additional tasks to complete.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

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RESIDENTIAL WELL SAMPLING

DO NOTs:

- DO NOT offer up information regarding sample results or health effects to homeowners during sampling. Such information, if not handled properly, can result in confusion or anger.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT leave air bubbles in VOA vials.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

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Attachment C: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use LDPE or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil. • Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. Field notes should be attached to the project-specific field book or folder upon returning to the office. • Do not use Post-It Notes during sample handling or mobilization/demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan (HASP) prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with sample collection and handling should wear nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
	gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up to sample a well.
1.6.1	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
2.2.2	Tubing used to purge and sample groundwater from a residential well for PFAS must not be LDPE or Teflon®. HDPE and silicone are acceptable.
2.3	LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable.
2.4 (b)	Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable.
2.4 (c)	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable.
4.3	Due to low reporting limit requirements for PFAS, trip blanks for PFAS analysis should be included in sample coolers if PFAS are being analyzed for in the associated residential well samples.

Notes:
[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

Aquifer Testing Procedures

Title: **Hydrocarbon Baildown Test**	Procedure Number: **ECR 017**
	Revision Number: **2**
	Effective Date: **October 2018**

Authorization Signatures

David Hay, Principal Author — Date 10/22/18	Keith Piontek, Contributing Author — Date 10/22/18
Nidal Rabah, Technical Reviewer — Date 10/22/18	Elizabeth Denly, ECR Practice Quality Coordinator — Date 10/22/18

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) describes the procedures, equipment, and important considerations for conducting a Hydrocarbon Baildown Test (baildown test). This test is used to estimate the transmissivity of Light Non Aqueous Phase Liquid (LNAPL[1]), or product, for assessing the recoverability of the product (Hawthorne and Kirkman, 2011; Charbeneau et al., 2012; ASTM, 2013; Hawthorne, 2013; Hawthorne and Kirkman, 2013; TRC, 2015).

This SOP should not constitute the documentation given to field staff to implement a baildown test. A shorter, more focused document providing clear instructions on the specific tasks to be implemented should be prepared from the information presented in this SOP. Specific project requirements, as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis (JHA), or Site-Specific Health & Safety Plan (HASP), will take precedence over the procedures described in this document.

1.2 Summary of Method

The baildown test can be performed on wells that exhibit accumulation of product floating on the groundwater in the well. The test is conducted by rapidly removing the product from a test well with a pump, vacuum truck, or bailer, followed by measuring and recording the product and water levels and times of measurement (product rebound data) until pre-evacuation levels are attained or nearly attained. Typically, this test is completed on wells exhibiting greater than 0.5 feet of product thickness and with a borehole diameter that is not large relative to the casing and screen diameter.

1.3 Responsibilities

The field staff performing this test are responsible for contacting the project sampling leader if there are any uncertainties about the test procedures or unusual observations in the field. The project sampling leader has the responsibility to oversee the tests and ensure that the tests are performed in accordance with the project-specific sampling program and this SOP.

1.4. Health & Safety Considerations

This section presents the generic hazards associated with conducting baildown tests and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP and JHA address additional requirements and will take precedence over this document. Note that baildown testing usually requires modified Level D personal protection (i.e., tyveks and chemically resistant gloves), unless there is a potential for exposure to airborne site contaminants.

[1] Commonly referred to as free-phase hydrocarbon, separate-phase hydrocarbon, free-product, liquid hydrocarbon (typically refined petroleum hydrocarbons such as gasoline, diesel, and other fuel products).

Health and safety hazards include, but are not limited to, the following:

- Slip, trip, and fall hazards in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure there is a safe means of access/egress to the wellhead.
- Hand cuts. Ensure the use of protective gloves.
- Dermal exposure to product. Ensure that proper personal protective equipment (PPE) is used to mitigate the impacts of product splashes to skin and/or eyes.
- Exposure to site contaminants. Take all precautions necessary to prevent fire, explosion, and/or exposure to airborne vapors from product in the well (especially gasoline).
- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment in the wells to preclude injury to the arms, shoulders, or back.

1.5 Personnel Qualifications

Because this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Field personnel qualifications and protective and monitoring equipment should be consistent with the HASP requirements. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These training requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.
- 8-hour HAZWOPER Supervisor training.
- First Aid/CPR training.

2.0 EQUIPMENT

The following equipment may be utilized to perform a standard baildown test. Project-specific conditions or requirements may warrant the use of additional equipment or omission of items from this list.

- Appropriate level of PPE, as specified in the site-specific HASP
- Health and safety equipment: appropriate air quality monitoring equipment (e.g., photoionization detector [PID], flame ionization detector [FID], multigas meter, etc.), caution tape or cones, etc.
- Equipment to evacuate product in the well (See Section 2.1):
  - Peristaltic pump and tubing;
  - Bailer and rope;
  - Vacuum truck; or
  - Other purging device.
- Decontamination solutions and equipment
- Spill control/containment material
- Measuring devices, including (See Section 2.2):

  - Electronic interface probe;
  - Pressure transducer (in addition to interface probe) – optional for use with rapid product rebound and/or emulsion at LNAPL/water interface;
  - Time piece (e.g., watch or other device);
  - Container for water and product collection that is graduated to measure within 10% of total estimated product recovery volume (unit conversion: 1 gallon = 3.785 liters = 0.134 cubic feet)
    - A container that can measure 0.1 gallon (~400 ml) for an expected 1 gallon (~4,000 ml) of recovered product;
    - A container that can measure 1 gallon (~4,000 ml) for an expected 10 gallons (40,000 ml) of recovered product.
- Project field book for recording field observations.

2.1 Product Removal Equipment

If the depth to product in the well is not too great, it is preferable to remove product with a peristaltic pump. Peristaltic pumps are intrinsically safe and low maintenance. The product does not come into contact with the pump, unless the tubing ruptures with age, a preventable condition with regular inspection. Additionally, water extraction can be minimized by controlling the depth of the tubing, with the benefit that the volume of recovered product can be accurately measured.

The theoretical suction (vacuum) lift limit of pure water at sea level is 33.9 feet (14.7 pounds per square inch [psi] atmospheric). However, this limit would only be obtained if a perfect vacuum were achieved in the pump. Typically, peristaltic pumps have a maximum working depth of 27 feet at sea level, 80% of the theoretical suction limit. This depth limit can be calculated for other liquids by dividing the maximum working depth by the specific gravity of the liquid.

- Gasoline, for example, with a specific gravity of 0.75, has a corresponding maximum working lift limit of 36 feet at sea level (27/0.75).

Atmospheric pressure and, therefore, suction lift diminishes with increase in elevation. At 2,000 feet, 4,000 feet, 6,000 feet, and 8,000 feet above sea level, the reductions in pure water suction lift are 2.3 feet, 4.8 feet, 6.9 feet, and 9.0 feet, respectively. The maximum working depth of the peristaltic pump at 4,000 feet, for example, would be reduced to about 22 feet for pure water (27 - 4.8), and to about 31 feet for gasoline (36 - 4.8).

A limitation of the peristaltic pump is the low rate of product removal at product depths near the suction lift limit, which may prevent attainment of near-instantaneous product removal (see Section 4.1). If the depth to product is too great for a peristaltic pump, then bailing or other removal methods can be used, if they are safe.

- Whale pumps and some other down-hole electric pumps cannot be used with product.
- Bailers and vacuum trucks extract some water. The removal of water generally introduces minimal error into the test data, if the equivalent water level in the well rebounds faster than the product thickness.

The Spill Buddy™ (Clean Earth Technology) is a good option for product removal from depths too great for a peristaltic pump. The Spill Buddy is a portable, intrinsically-safe, battery-operated electric pump equipped with a product/water interface sensor. The 1.93-inch diameter pump fits in 2-inch diameter wells and can recover product at a rate up to 0.7 gallons per minute (gpm) from depths up to 100 feet. The battery is rechargeable from a 12V DC source (car battery or cigarette lighter socket) or the AC transformer provided with the unit.

In some cases when attempting to completely purge product from the well, the available product removal equipment will not be able to remove product at a rate at least as high as the inflow rate. In these cases, a modified test approach is needed (see Section 4.4, Test Modifications).

2.2 Measuring Devices

Typically, the air/product and product/water interfaces will be gauged using an interface probe. With this procedure, there is an unavoidable variable time lag between the two measurements that could introduce significant error in the calculated thickness for the recorded time.

When the product rebound occurs rapidly (i.e., less than one hour), tests should be conducted with a data logger (pressure transducer) set near the bottom of the well (in the water phase). Use of a pressure transducer is also recommended for LNAPL densities similar to water, whereby bailing generates an emulsion that causes erratic interface probe readings of the LNAPL/water interface. In these cases, the field staff will only need to measure the depth to the air/product interface following removal of product, resulting in less measurement error, as well as less error in the calculated thickness. Measuring the air/product interface is simpler and results in more accuracy than measuring the product/water interface when using a pressure transducer.

If a pressure transducer is used, it should be a gauge pressure (vented) type, especially if the product occurs under confined conditions. A pressure transducer measures the pressure, or total head, above it. The head attributed to the water and to the product must be calculated. The density of the product must be known in order to calculate the head of each phase contributing to the total head. With measurements of the depth to the air/product interface, the following equations are used to estimate the depth to the product/water interface:

$$PW = AP + b_o$$

$$b_o = \frac{(PT - H_t - AP)}{1 - (\rho_{product}/\rho_{water})}$$

Where:

PT	=	Depth to pressure transducer measuring point (ft)
H_t	=	Total head in terms of water measured by pressure transducer (ft)
AP	=	Depth to air/product interface as gauged (ft)
PW	=	Depth to product/water interface (ft)
$\rho_{product}$	=	Density of product (g/cm^3)
ρ_{water}	=	Density of water (g/cm^3)

b_o = Measured product thickness in well (ft)

PT can be estimated by measuring the transducer cord, but it should be calculated for more accuracy before the test is started using measurements of PW and AP. PT can be calculated after the pressure transducer is in place (in the water phase) using the following equation:

$$PT = PW + H_t - (PW - AP)(\rho_{product}/\rho_{water})$$

The error associated with the rebound rate calculations is directly related to the error in gauged product/water and/or air/product interfaces. Small pre-test equilibrium product thickness either results in few data points collected (for rapid rebound) or data points representing very small changes in product thickness. Based on the accuracy of estimating the product/water and air/product interfaces with available interface probes, it is possible, but not recommended, to perform baildown tests at wells with a gauged equilibrium product thickness less than 0.5 ft. Baildown testing should not be performed at wells with a measured product thickness less than 0.2 ft.

3.0 PRE-TEST PREPARATION

Refer to the project-specific plans, if applicable, for site-specific procedures. Other state or federal requirements may be beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field book.

The following assumptions and conditions are necessary to perform a valid test:

- The thickness or volume of product in the well is not affected by the volume of the measuring device inserted into the floating layer of product.
- The volume of removed product can be accurately measured.
- There must be equilibrium between the product in the well and the product in the geologic media (formation sediment or rock).
- For product that occurs under unconfined conditions, the air/product and product/water interfaces must be within the screened interval of the well.
- The borehole diameter must not be excessively large relative to the casing and screen diameter.

The following well construction information needs to be obtained and recorded prior to initiating the baildown test:

- Borehole diameter of well to be tested
- Casing and screen diameter
- Depth to top of screen from top of casing
- Depth to top of filter pack/base of seal
- Bottom of screen interval
- Total well depth

3.1 Well Borehole Diameter

Baildown test data analysis is typically based on an assumption of "instantaneous removal" of product from the well. Instantaneous is relative to the rate of product rebound due to inflow from the geologic medium (see Section 4.1). Rapid removal of product in the well cannot be accomplished if there is a large volume of product stored in the filter pack. Product in the filter pack of a well does not drain instantaneously into the casing and well screen, and the rate of drainage decreases as the product saturations and relative permeability decrease. Furthermore, for unconfined conditions, if the water rebounds quickly (with or without water removal), the water will impede product drainage from the filter pack below the water table elevation (R. Charbeneau, personal communication, April 2015). The extended time required to evacuate enough product from a large diameter well with a small casing and screen diameter to attain significant product drawdown to begin rebound measurements may violate the assumption of instantaneous removal. Therefore, the well diameter must not be excessively large relative to the casing and screen diameter.

The ratio of casing volume/drainable filter pack volume decreases from approximately 1.6 for 2-inch casing and screen in a 4.25-inch diameter borehole to approximately 0.38 for the same well materials in an 8-inch diameter borehole (assuming filter pack product storage coefficient of 0.175). Baildown testing in wells with a large casing/borehole diameter ratio is preferred for the following reasons:

1) Less pumping/bailing time to achieve a given product drawdown in the well,
2) Faster attainment of product inflow from the geologic medium without simultaneous filter pack drainage and, therefore, faster generation of the appropriate data for analysis of transmissivity, and
3) More product inflow from the geologic medium for a given baildown volume (given the limited spatial influence of the test, the more influence the better).

3.2 Equilibrium Conditions

Because baildown tests are used to evaluate the transmissivity of product in the subsurface, equilibrium between the product in the well and the product in the geologic media is essential for a valid test result. Periodic product removal events can generate nonequilibrium conditions and result in inappropriate liquid levels at the start of the test. Equilibrium liquid levels are required for accurate product drawdown calculations.

For product occurrences under confined conditions, the proper equilibrium conditions include the column of product accumulation in the well extending to the base of the zone of mobile product in the confined stratum, potentially well below the top of the screen. Transmissivity calculations using the American Petroleum Institute (API) spreadsheet for confined product cannot be performed without specifying initial conditions in the input that include the product/water interface below the top of the screen.

The depth to product (DTP) and depth to water (DTW) should be measured at least 8 hours before the test and then immediately before the start of the test to confirm that liquid levels are stable and in equilibrium with the geologic media. The ASTM standard (ASTM, 2013) recommends collecting pre-test gauging data for a time period that is equal to the length of the expected rebound period based on previous evacuation events. These pre-test data should show consistent equilibrium liquid levels. If the well has not been previously tested, record post-rebound liquid levels for the same length of time as the rebound period to confirm equilibrium conditions. Avoid conducting the test during precipitation.

If the length of time for full product rebound is known from previous extraction events and subsequent gauging, it is good practice to remove product from the well before the test day to ensure stable and equilibrium liquid levels on the test day. If the rebound rate is high (i.e., the product in the well rebounds in an hour or less), the testing procedures described in Section 4.4 should be considered.

4.0 TEST PROCEDURES

The following general protocol should be followed to conduct a baildown test:

1. Start the baildown portion of the test early in the day, because the measurement frequency is highest in the first 8 hours of the product rebound.

2. Measure and record the static depth to product and the static depth to water. Record the time of measurements.

3. Calculate the volume of mobile product in the well (casing and filter pack).

4. If there is potential for equivalent groundwater levels to vary during testing, depths to groundwater can be measured in a nearby product-free control well before and during testing. Variations in equivalent groundwater levels during the product rebound affect depths to product and product thickness that may potentially invalidate the test.

5. To start the test, remove all (or a substantial fraction) of the mobile product in the well casing and filter pack in a short time frame. Note that the method of analysis does not require removal of the entire volume of mobile product, but removal of as much product as possible in a relevant time frame is recommended (see Section 4.1). Fully removing the mobile filter pack volume results in observing the correct trend of drawdown versus discharge for analysis sooner than partial removal, but the time required for complete removal may be inappropriate (see Sections 3.1 and 4.1).

6. Record the start and finish times of product removal. Record the total volumes of product and water removed. If large volumes (over 5 gallons) of product are removed, or product removal occurs over an extended period of time (more than 30 minutes should generally be avoided, but may be acceptable for wells that rebound very slowly), record several interim measurements of the product and water volumes removed and the times. To minimize groundwater removal, use transparent tubing for monitoring the liquid being extracted to indicate which liquid, product or water, is being removed.

   The length of time required for product removal should be small relative to the product rebound time. As a general rule, remove a volume of product up to the calculated mobile product volume. Smaller volumes of product removed result in a closer approximation to an instantaneous head change, but filter pack recharge affects increase. Larger removal volumes minimize filter pack recharge effects, but may result in a substantial deviation from an instantaneous head change.

7. Begin measurements and recording of the times and the depths to the air/product and product/water interfaces immediately after removing the product. If the product thickness appears to be decreasing at any time during the product rebound measurements, re-measure and/or check the product/water interface probe.

8. In the first 100 minutes of product rebound, try to take measurements at every change in product thickness of 1 percent of the equilibrium thickness (The minimum practical time interval for gauging measurements is generally 1 minute). After 100 minutes, take measurements at every change in product thickness of 5 to 10 percent of the equilibrium thickness. The following measurement frequencies are recommended as an alternative to the thickness change criteria, particularly if adherence is not achievable early in the rebound:

   - First 10 minutes of rebound: every 1 minute (10 measurements)
   - 10 to 20 minutes: every 2 minutes (5 measurements)
   - 20 minutes to 40 minutes: every 5 minutes (4 measurements)
   - 40 minutes to 2 hours: every 10 minutes (8 measurements)
   - 2 hours to 4 hours: every 30 minutes (4 measurements)
   - 4 hours until the end of the first day (8 hours or greater): every 1 hour
   - Second day: 2 to 3 measurements
   - After second day: 1 measurement per day until the product thickness stabilizes

During the test, accurate measurements of the depths to product and water are critical. Ensure that these readings are consistent and reliable. Do not simply record numbers - study them and determine if they make sense.

- Product thickness should increase (or remain the same) from one measurement to the next, not decrease.
- Depths to the air/product interface should be decreasing (or remain the same), and depths to the product/water interface should be increasing (or remain the same).

Re-measure and report any readings that seem anomalous. Make notes regarding the methodology used to confirm or revise anomalous data. The test data should be faxed, phoned, or e-mailed to the office for review and analysis on a daily basis, if possible.

When the product transmissivity or rebound time length is not known, plan to start the baildown portion of the test early in the work day and on a day when you will be able to return frequently to the well. This precaution will ensure that a sufficient number of measurements can be obtained within the first 8 hours of the test.

If tidal fluctuations are expected, the DTP and DTW must be measured regularly for at least a week leading up to the test. The test should be conducted at high or low tide and repeated at the other extreme of the tide. Depending on the product transmissivity, the product rebound time may be longer or shorter than the tidal cycle. If the rebound is shorter than the tidal cycle (high product transmissivity), there will likely be a substantial difference in transmissivity at high and low tides. Testing at both low water table and higher water table conditions may also be appropriate at sites where groundwater levels are affected by river stages.

4.1 Product Baildown

The evacuation of product from the well for initiation of the test should be rapid (near "instantaneous") and performed in a manner that removes as little groundwater as possible. Product in the casing/screen and filter pack must be removed. Commercial pumps such as a peristaltic pump or Spill Buddy™ are preferred for product removal because the pump intake can be located to remove only the product during the baildown stage of the test. If a bailer is used, then additional precautions are necessary to (i) remove as little water as possible and (ii) minimize liquid disturbance during product removal.

Good judgment must be used for the product evacuation time, which is based on an estimate of the total volume of mobile product in the casing and filter pack, an estimate that is likely conservative, especially considering the decreasing relative permeability as the product drains from the filter pack. The ASTM standard (ASTM, 2013) specifies that the "instantaneous" evacuation should occur in a time that is 1/100th or less of the total expected test duration (rebound period), a duration that should be based on previous extraction events and subsequent gauging. Unless the product transmissivity is very low, significant drainage of product into the well from the geologic medium may occur before the estimated volume of mobile product in the well can be evacuated, especially with large storage in the filter pack, violating the conditions for testing. A different method of evacuation may be required.

The following equations can be used to estimate the mobile volume of product within the well for unconfined conditions with the screen across the interval of product in the well:

$$V_c = \pi r_c^2 b_o$$
$$V_a = 0.175\pi(r_b^2 - r_c^2)b_o$$
$$V_t = V_c + V_a$$

Where:

V_c = Volume of product in the casing and screen (ft^3)

V_a = Volume of product in the well annulus (ft^3)

V_t = Total effective volume of product in the well (ft^3)

r_c = Well casing or screen radius (ft)

r_b = Well borehole radius (ft)

b_o = Measured product thickness in well (ft)

The factor 0.175 is an estimate of mobile product storage in the filter pack, assuming that 50 percent of the filter pack porosity (assumed 35 percent) is occupied by drainable product, with the other 50 percent occupied by residual (immobile) product and/or water and air. It is also assumed that the filter pack product saturations are uniform throughout the corresponding interval of product occurrence in the screen.

For confined product, the following procedures may be applicable for estimation of the volume of mobile product in the well:

- If the screen extends across the confined unit only or also partly into the confining unit, the estimated volume of mobile product in the well is calculated based on the casing and screen volume plus the drainable product in the filter pack from the top of the filter pack to the base of the product column in the well.
- If the screen extends across and above the confining unit into overlying sand, and the air/product interface is within the screened interval, the length of the product column in the well is used to estimate the volume of mobile product in the filter pack.

For perched product intersecting the screen, the filter pack volume is based on the length of the product column across the screened interval (assuming no filter pack below the screen and no product extending below the screen).

There are many well construction and product occurrence scenarios, and it is prudent to consult the LNAPL Conceptual Site Model SOP (TRC, 2015) and to sketch the site-specific relationships to properly calculate filter pack product volumes.

Depending on the well construction and product thickness, it may take more than 1 hour to remove the mobile volume of product in the casing and filter pack. Note that for unconfined conditions, if the water rebounds quickly (with or without water removal), the water will impede product drainage from the filter pack below the water table elevation (R. Charbeneau, personal communication, April 2015), and obtaining the calculated volume may not be realistic. An extended time period may be acceptable for wells that require several days to a couple of weeks to rebound. However, excessive removal times should be avoided. Removal of a product volume less than the calculated volume of mobile product in the casing and filter pack may be sufficient. The filter pack drainage effect can be recognized during data analysis, and the data representing this drainage can be avoided in the analysis.

If four hours of product removal efforts have passed without obtaining the mobile product volume, rebound measurements should begin, if the volume of product removed is at least 50% of the objective (R. Charbeneau, personal communication, April 2015). The well construction and product volume calculations should be checked. The rebound data could potentially represent only drainage of the filter pack, if the casing and screen diameter are small in a large diameter borehole. If the analysis suggests a repeat of the test should be undertaken, a different evacuation method may be necessary.

4.2 Product Rebound Data Collection

Following the removal of product from the well, rebound measurements begin immediately. The rate of product thickness change during rebound is typically logarithmic, therefore measurements must be closely spaced in time during the early phase of the rebound. The minimum practical time interval for gauging measurements is generally 1 minute. Measurements may be taken at progressively greater time intervals as the rates of change of the depths of the air/product and product/water interfaces diminish. Complete rebound may take several weeks or months. In later stages of rebound, measurements may only need to be taken weekly or even monthly.

API guidance (Charbeneau et al., 2012) suggests that a record of 20 to 30 measurements (each for DTP and DTW [if a data logger is not used]) is generally adequate for data analysis. When possible, these measurements should be evenly spaced in terms of the rebound thickness. For example, if the initial product thickness in a well is 3 ft, and the product thickness after baildown is 0.5 ft, then measurements might be taken when the product thickness attains the following sequence of values: 0.5, 0.6, 0.7, 0.8 0.9, … 2.9, 3.0 ft. Another "rule of thumb" is measurement each time the product thickness increases no more than 5 to 10 percent of the original equilibrium product thickness (e.g., if the initial product thickness is 3 ft, measurements should be taken every time the product thickness increases 0.15 to 0.3 ft). The rapidity of rebound may dictate the minimum thickness increment and the number of measurements attainable.

After the first 100 minutes of rebound, the data should be reviewed and a schedule generated by the field staff for additional measurements. For example, if the product rebounded less than 5 percent of its initial thickness in the first 100 minutes, the next measurement would be at least 100 minutes from the last measurement. After 4 hours of rebound, the data should be reviewed again for revision of the measurement schedule. If previous knowledge of the rebound behavior of a given well is available, this information can be used to revise the schedule. An example of measurement intervals is provided in Attachment B.

4.3 Test Duration

The scope of work may include planning for gauging to be conducted for several days or even weeks, especially if the pre-test equilibrium thickness and liquid levels are uncertain. This scope may be feasible, if other work is being performed on the site, or the site is local and the client is willing to fund periodic site visits. Plan on obtaining rebound measurements until the product thickness stabilizes, optimally to its pre-test thickness to confirm it was at equilibrium. Otherwise, a one-day test or two-day test may be proposed (depending on the client and/or stability of the potentiometric surface), with a measurement on the morning of departure from the site. These data could be evaluated, with recommendations for longer testing, if necessary, if the data are inadequate to make a defensible determination of transmissivity. In extremely low product transmissivity cases, it is possible that no product rebound would be observed in this time frame, potentially leading to the wrong conclusion of no mobile product. A provision of the work scope should include a recommendation for return to the site after weeks or even months to establish either the absence of mobile product or extremely low transmissivity. If product finally appears or very slowly rebounds during an extensive time, this information is valuable in negotiations with regulators and/or determinations of product recovery feasibility. However, the stability of the potentiometric surface during the extended period of observation must be taken into consideration for the interpretation.

Also, for low product transmissivity, the time requirement for gauging until equilibrium might be excessive, and early termination of measurements will be necessary. In this case, before terminating rebound measurements, the partial data set could be evaluated to assess adequacy for calculating transmissivity. If the data are inadequate, a plan could be developed based on the rebound rate for subsequent visits to the site to obtain the requisite data, including the equilibrium liquid levels. Full rebound may be especially important for confined and perched product conditions, to verify the conceptual site model and to correctly estimate transmissivity, if equilibrium liquid levels are unknown.

A typical indication that the product thickness is stabilizing is a product thickness that is nearly constant for about a half log cycle of time. This stabilization should be verified with 3 measurements during that half log cycle. A semi-log plot of the rebounded product thickness versus time (e.g., Attachment B) will assist in the assessment of stabilization and test completion.

4.4 Test Modifications

In some cases, the product in a well rebounds faster than it can be removed. This phenomenon becomes apparent after the calculated well volume has been removed. In these cases, a manual skimming test should be conducted.

The manual skimming test consists of the removal of product from a well on a repeated basis, without permitting more than approximately 25% product rebound to occur between removal events. The objective is continued purging of the product until a steady-state product inflow rate is attained. The frequency of removal is, therefore, dependent on the well inflow rate. Product transmissivity is calculated from the steady-state product inflow rate and the drawdown corresponding to that rate. Note, however, that very specific criteria are used to determine the drawdown for the transmissivity analysis (ASTM, 2013), which is not simply the length of the column of product removed at 20 or 25% rebound.

A manual product skimming test can be conducted in any well with a gauged product thickness. The manual skimming test provides an advantage over a standard baildown test because the repeated product removal events result in stressing a larger area of the formation.

A manual skimming test can be conducted with a peristaltic pump or a pneumatic skimmer pump. Two people would be needed if a bailer is used. The procedures for this test are outlined below:

- The pre-test liquid levels are measured and recorded. These levels must represent equilibrium.
- The product is removed from the well, permitted to rebound at least 20%, removed again, permitted to rebound the same amount, etc. until a constant inflow rate is attained. The inflow rate can be low, but must be measurable and documented.
- The start and end times of product removal are recorded.
- The volume of product from each removal event is measured and recorded.
- Liquid levels are measured between removal events, and the levels and times of measurement are recorded.
- The product inflow rate is determined from the volume of product removed during each purging event and the time for the product to rebound 20 to 25%.
- If a bailer is used for product removal, then one person bails while the second person measures the liquid levels. The liquid level measurements are taken immediately before and immediately after a bailer is removed, then subsequently during product rebound.
- For fast rebounding wells that preclude complete product removal, after the product thickness and elevation of the air/product interface stop decreasing, terminate product removal efforts and start measuring the liquid levels as frequently as possible.
- After completion of the testing, gauge the liquid levels until they stabilize at the pre-test equilibrium levels.
- If product rebound is very fast, the test could be repeated to improve execution or for

verification. Perform the repeat test by removing the product over the same time period as the previous test. The test could be repeated several times, if it is necessary to improve the techniques and data collection.

5.0 INVESTIGATION-DERIVED WASTE DISPOSAL

A plan must be developed for disposal of investigation-derived waste (IDW). Recovered product and groundwater and other wastes produced during the testing should be handled, containerized, labelled, stored, and transported in accordance with the HASP, hazard communication plan, and state and Department of Transportation (DOT) requirements. Field personnel should be familiar with the project-specific requirements for IDW.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

When a pressure transducer/data logger is used, take periodic manual measurements of the depth to the product/water interface as a check on the transducer readings and the calculated levels. All equipment should be decontaminated between tests on different wells according to TRC SOPs. The rope used for the bailer should be replaced between tests on different wells.

7.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The field baildown test data form (Attachment A) must be completed for each test. A project field book should also be used for recording relevant information. These documents provide a summary of the test method and data, site conditions, and weather conditions. These documents will be kept in the project files for reference and reports. Attachment B provides an example data set of product thickness vs. time.

8.0 DATA INTERPRETATION

Guidance on the interpretation of test data and estimation of product transmissivity can be obtained from Charbeneau et al. (2012), ASTM (2013), and TRC (2016).

9.0 REFERENCES

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Charbeneau, R.J., Kirkman, A., and Muthu, R., 2012. User Guide for API LNAPL Transmissivity Workbook: A Tool for Baildown Test Analysis. API Publication 46xx (pre-publication draft). Prepared for: American Petroleum Institute.

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10.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVIEW
0	SEPTEMBER 2015	NOT APPLICABLE
1	MARCH 2016	ADDED SECTION ON IDW
2	SEPTEMBER 2018	ADDED TEXT TO ADDRESS LNAPL/WATER INTERFACE FOR LNAPLS SIMILAR IN DENSITY TO WATER

Attachment A

Hydrocarbon Baildown Test Form

Hydrocarbon Baildown Test Form

Site:	Proj. No:
Well:	Sampler(s):
Well Information	**Product Information**
Casing Diameter	Liquid Type
Total Depth	Viscosity
Depth to Top of Screen	Density
Screen Length	Color
Screen Diameter	Depth to Top of Filter Pack
Borehole Diameter	Depth to Bottom of Screen Interval

Baseline and Baildown Data

Baildown Method (Specify bailer or pump, describe type and/or size of device)	

Date/Time	**Initial Depth to Product (ft.)**	**Initial Depth to Water (ft.)**	**Product Thickness (ft.)**	**Target Product Removal Volume (gallons)**

Baildown Volume Tracking

Date	**Time**	**LNAPL Removed (gallons)**	**Water Removed (gallons)**

Product Rebound Data

Date	**Time**	**Elapsed Time (min)**	**Depth to Product (ft)**	**Depth to Water (ft)**	

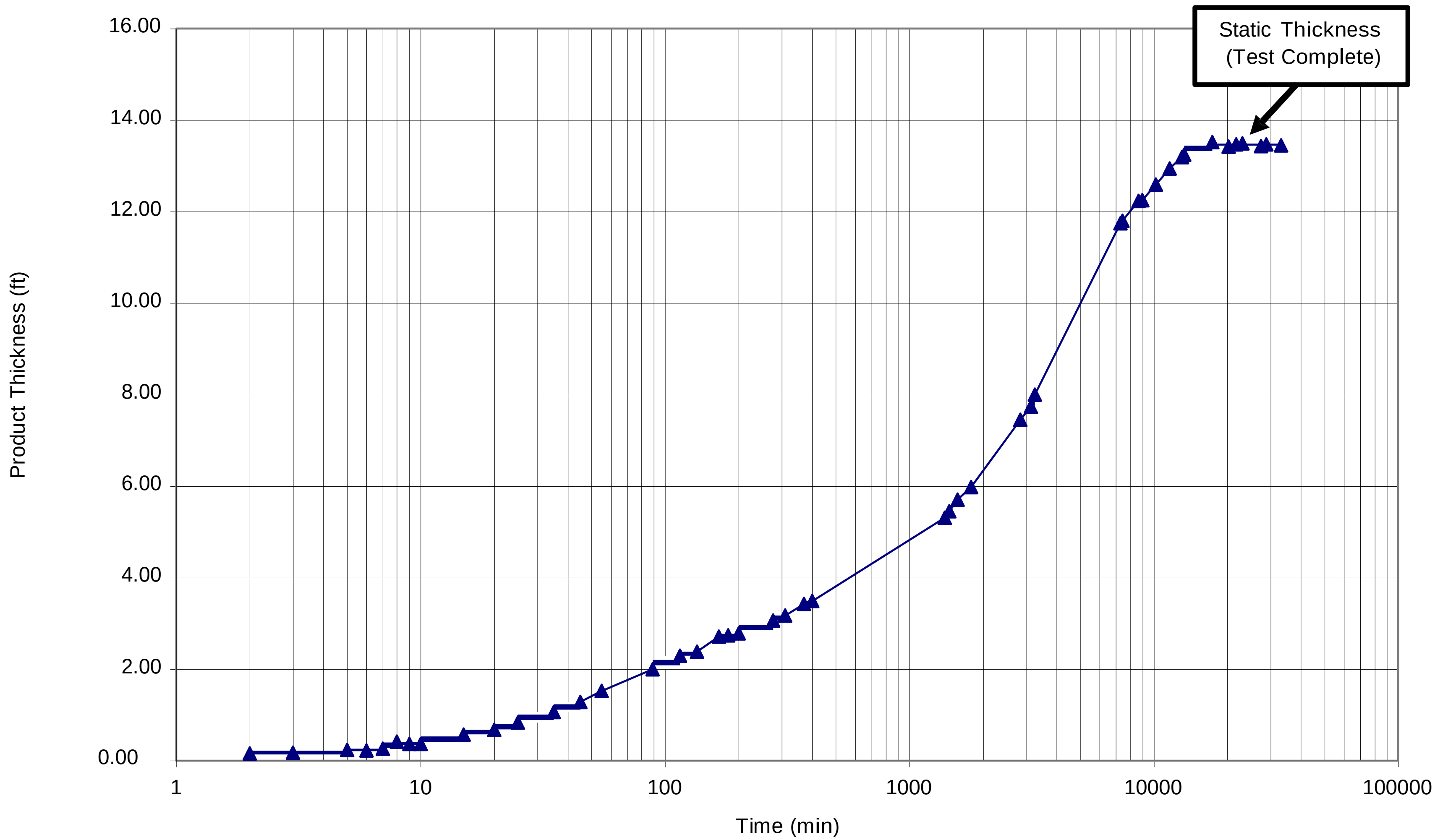
Well:_______________ **Hydrocarbon Baildown Test Form** Page __ of __

Product Rebound Data (continued)					
Date	**Time**	**Elapsed Time (min)**	**Depth to Product (ft)**	**Depth to Water (ft)**	

Attachment B

Example Product Thickness Rebound Data Figure

Example Product Thickness Rebound Data Figure



Title: **Pumping Tests**	Procedure Number: **ECR 022**
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Authorization Signatures	
David Hay	Elizabeth P. Schwartz
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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in the design, procedures, and equipment for performing groundwater pumping tests. The information in this SOP was compiled from standard textbooks of groundwater engineering and hydrogeology (Driscoll, 1986; Delleur, 1999; Fetter, 2001), publications by the United States Environmental Protection Agency (USEPA, 1993) and the Ohio EPA (2006), and short course materials on aquifer testing provided by the Midwest GeoSciences Group (2007).

A pumping test is a field experiment in which a groundwater well is pumped at a controlled rate or variable rates. Water level response (drawdown) is usually measured in the pumping well (control or test well) and in observation wells. Response data from pumping tests may be analyzed to estimate the large scale average hydraulic properties (transmissivity, hydraulic conductivity, and storage coefficient) of water-bearing geologic units. Water-bearing units are defined as geologic units with primary and/or secondary porosity that is 100 percent saturated with groundwater, which include aquifers and aquitards. This SOP uses the term "aquifer" for any water-bearing unit in which a well is completed and used to perform a pumping test. Response data may also be used to determine the vertical hydraulic conductivity of confining units (aquitards) and to identify potential aquifer boundaries (recharge and barrier). Aquifer test and aquifer performance test are alternate designations for a pumping test.

The purpose of performing a pumping test will determine the course of test planning and design. A pumping test may be conducted for the purpose of evaluating well performance, or assessing environmental impacts of pumping, and/or determining the hydraulic properties of the aquifer.

A pumping test without observation wells is commonly performed to assess well performance (yield). These tests are usually conducted by water well drillers for short durations (2 to 12 hours) without systematic water level measurements in the pumped well. The pump is generally operated at maximum capacity with little or no attempt to maintain constant discharge. Discharge rates for this type of test typically unintentionally vary as much as 50 percent (USEPA, 1993). Furthermore, the measured drawdown during pumping is partly a function of well losses. As a result, the data from these tests may only be suitable for obtaining very rough estimates of aquifer properties (*i.e.,* transmissivity), unless good records were kept of the flow rates, and recovery data were recorded.

The types of pumping tests performed to determine aquifer properties include step-drawdown and constant-rate tests. Step-drawdown tests proceed through a sequence of constant, incrementally-increasing pumping rates at the control well to determine well performance characteristics (well loss and well efficiency), which may be used to select the optimum pumping rate for a long-term constant-rate test.

A constant-rate test requires maintaining a single pumping rate at the control well for the duration of the test. This pumping test is the most commonly used method for obtaining estimates of large-scale average aquifer properties. Test duration may range from 6 hours to generally no more than 72 hours, depending on the desired scale of assessment and/or whether aquifer boundaries may be intersected by the cone of depression. One of the reasons for conducting a long-term pumping test is to evaluate the potential for the occurrence of recharge or barrier boundaries and their effects on well performance. A long-term test may be necessary to assess leakage across a semi-confining unit and its hydraulic conductivity, which may have implications for drawdown in the adjacent aquifer or for transport of contaminants across the confining unit. Other reasons for performing long-term tests are assessments of aquifer heterogeneity and anisotropy. Large-scale average aquifer properties are commonly useful for contaminant migration assessments and for design of capture, water supply, and construction dewatering systems.

Another type of pumping test is a constant head (constant drawdown) test in which the water level in the control well is held constant while discharge is monitored and recorded. A flowing artesian well is a case in which a constant head pumping test would be used. This SOP is written for step-drawdown and constant-rate pumping tests, but much of the information is also applicable to the constant head pumping test.

A pumping test can be a major, expensive investigative technique, especially if new wells must be installed, and if the tested aquifer is deep and prolific. A test using existing wells, if possible, can minimize costs. Proper planning, design, execution, and data interpretation are essential.

This SOP is not a substitute for the development of a project-specific work plan to be provided to field staff for conducting the pumping test. A shorter, more focused document for the field crew, providing clear instructions on the specific tasks to be implemented, should be prepared from the information presented in this SOP and the work plan. Specific project requirements, as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan (QAPP), Job Hazard Analysis (JHA), and/or Site-Specific Health & Safety Plan (HASP), will take precedence over the procedures described in this document.

1.2 Components of a Pumping Test

There are four components of a thorough pumping test evaluation: 1) monitoring background water levels prior to the step-drawdown test to establish ambient/baseline water level trends for correcting drawdown data; 2) the step-drawdown test to determine the sustainable pumping rate for the constant-rate test; 3) the constant-rate test (drawdown phase); and 4) water level recovery monitoring (recovery phase).

2.0 DEFINITIONS AND ABBREVIATIONS

Aquifer	A groundwater-saturated, permeable geologic formation, group of formations, or part of a formation capable of yielding (storing and transmitting) a significant amount of groundwater to wells or springs.
Aquifer Test	A test to evaluate hydrogeologic properties of an aquifer involving the withdrawal or addition of measured quantities of groundwater from a well, and the measurement of resulting changes in head in the aquifer, both during and after the period of discharge or addition. Also referred to as pumping test or aquifer performance test.

Aquitard	A groundwater-saturated, low permeability geologic unit that transmits (and stores) water at very low rates (significantly less than adjacent aquifers).
Artesian Aquifer	A confined aquifer that has hydraulic head above the top of the aquifer. A flowing artesian aquifer has hydraulic head above the ground surface and is penetrated by a well.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Confined Aquifer	A fully-saturated aquifer overlain by a confining unit that has significantly lower hydraulic conductivity than the aquifer.
Confining Unit	A geologic unit that inhibits flow between aquifers.
Dense Non-aqueous Phase Liquid (DNAPL)	A liquid that is immiscible with, and denser than, water.
Depth To Water (DTW)	The distance to the air/water interface from an established measuring point, commonly a notch at the top of a well casing.
Drawdown	The decline in hydraulic head observed at a well in response to pumping.
Flame Ionization Detector (FID)	An instrument that uses a hydrogen flame to ionize gas molecules for detection and measurement of volatile organic compound (VOC) concentrations.
Flush Mount	A type of well completion whereby the riser terminates at or below grade. Flush-mounted wells are typically completed with a “curb box”, which is an “at-grade” enclosure designed to protect the well riser.
Hydraulic Conductivity (K)	A proportionality constant relating hydraulic gradient to specific discharge. This constant describes the rate of water movement through a medium in a unit of time under a unit hydraulic gradient through a unit area perpendicular to the direction of flow.
Light Non-aqueous Phase Liquid (LNAPL)	A liquid that is immiscible with, and less dense than, water.
Monitoring Well	A well to obtain water quality samples and/or measure groundwater levels.

Photoionization Detector (PID)	An instrument that uses an ultraviolet light source to ionize gas molecules, commonly for the detection and measurement of volatile organic compound (VOC) concentrations.
Protective Casing	The steel or aluminum case with a locking cap installed around the well riser (casing) that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) for security and damage protection of the well.
Recharge Rate	The rate of net infiltration of precipitation.
Specific Capacity	An expression of well performance in terms of the yield per unit drawdown.
Static Water Level	Non-pumping water level in a well, which is at equilibrium with atmospheric pressure.
Transmissivity (T)	The rate at which water of a prevailing density and viscosity is transmitted through a unit width of a saturated medium under a unit hydraulic gradient. It is equal to hydraulic conductivity times saturated thickness.
Unconfined Aquifer	An aquifer that has an overlying unsaturated portion (zone). The top of the saturated zone commonly has negative capillary pressure.
Water-bearing Unit	A geologic unit with primary and/or secondary porosity that is 100 percent saturated with groundwater.
Well Filter Pack	A granular material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.
Well Screen	Pipe (typically polyvinyl chloride [PVC] or stainless steel) used to retain the formation or filter pack materials of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The selection of well screen characteristics is based on formation grain size and filter pack material specifications.

3.0 PERSONNEL QUALIFICATIONS

TRC personnel must be trained for precautionary measures and emergency response at sites of potential exposure to toxic chemicals and/or sites with hazardous environments. Project- and client-specific training requirements should be included in the project-specific work plan and site-specific HASP. These requirements include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER),
- 8-hour annual HAZWOPER refresher training.

- Field personnel must be trained in conducting activities associated with this test.

3.1 Health & Safety Considerations

TRC personnel shall follow the site-specific HASP, including use of the appropriate level of personal protective equipment (PPE). If the HASP indicates that the groundwater in the pumping well and observation wells may contain measurable levels of VOCs, the well heads should be screened using a PID and/or FID to potentially avoid inhalation of contaminants venting from the wells and/or the discharge water. If these monitoring results indicate elevated concentrations of VOCs, the level of PPE may need to be increased in accordance with the HASP. If LNAPL or DNAPL occur in the wells, contact with these contaminants should be avoided.

For safety and avoidance of error associated with fatigue, a work shift should be no longer than 12 hours. A minimum break time of 8 hours is recommended.

4.0 DOCUMENTS, EQUIPMENT, ACCESSORIES AND SUPPLIES

The following items are commonly used to perform pumping tests. Site-specific conditions may warrant the use of additional or less equipment.

Documents

- Project-specific work plan and site-specific health and safety plan (HASP)
- Discharge permit (*e.g.,* National Pollutant Discharge Elimination System [NPDES] and withdrawal permit, as applicable (*e.g.,* New jersey Department of Environmental Protection requires allocation permit for extraction rates >100,000 gallons per day [gpd] for more than 30 days)
- Map of well locations
- Topographic map
- Potentiometric surface map
- Historic water level and quality records for control and observation wells used in the test
- Well construction data and well construction logs for reference
- Equipment manufacturer operating manuals

Equipment

- Submersible pump(s) for expected or needed maximum (and minimum) flow rate and lift, with sufficient suspension cable and electric cable for pump depth and distance to generator
- Pump cooling shroud to allow the pump to be set near the bottom of the well. The shroud forces water around the pump motor, which is below the pump intake
- Generator (must be compatible with pump) and backup generator, if a reliable power source with adequate capacity is not available

- In-line water meter to measure discharge from the pumping well, which displays the instantaneous flow rate and the total pumped volume
- Data-logging pressure transducers (*e.g.,* In-Situ, Inc. Level Troll® Model 700 vented pressure transducers), one per well, rated for appropriate water depths
  - Vented/gauge pressure transducers are recommended for unconfined aquifers, but total pressure/absolute transducers may be used for both unconfined and confined aquifers with on-site barometers.
  - Use the same type of transducer for all wells, but select the transducer range specifically for the well.
  - The Level Troll 700 is available in 5, 15, 30, 100, 300, and 500 pounds per square inch gauge (psig) ranges. Accuracy is about 0.1% of the full scale. For example, a 5 psig transducer has an accuracy of ±0.005 psi (±0.01 ft of water), but a range of only 5 psi (11.6 ft of drawdown). A 30 psig transducer has a 30 psi range (69 ft) and an accuracy of ±0.07 ft water (±0.1% of full scale).
  - High pressure range transducers are usually used in the control well and nearby observation wells, whereas low pressure range transducers are used in distant observation wells.
  - Do not use a 5 psig transducer in your pumping well, if you expect >10 ft of drawdown. Similarly, a 30 psig transducer is inappropriate for a distant observation well, where only 0.1 ft of drawdown is expected.
- Digitally-recording barometers (*e.g.,* In-Situ, Inc. BaroTroll®) to correct data from absolute pressure transducers for atmospheric pressure variations and/or calculate barometric efficiency (typically important for confined aquifers)
- Rainfall gauge
- Laptop computer with instrument control software (to set up and download data from transducers)
- Electronic water level sounder capable of measuring to 0.01 foot accuracy
- Multi-parameter water quality meter (*i.e.,* conductivity, pH, temperature meter)

Accessories & Supplies

- Appropriate level of PPE, as specified in the HASP
- Appropriate field monitoring equipment (*e.g.,* PID), as specified in the HASP
- Backflow check valve – for installation at base of discharge pipe
- Discharge tubing – enough for depth of pump and to discharge at sufficient distance from the well in the groundwater downgradient direction to avoid recharging the cone of depression
- Hose clamp
- Twist ties to secure electric cable and tubing
- Generator fuel – sufficient for pumping time (fuel must be stored safely and properly)
- Flow controller for use with submersible pump (compatible with pump)
- Winch or drilling rig to lower/raise pump

- Extra batteries for meters/controllers
- Discharge sampling supplies, including sample tap, sample bottles, and sampling forms
- Well lock keys
- Bolt cutters for rusted locks or locks without keys
- Appropriate tools for equipment and to open well box (*e.g.,* socket wrench, pry bar, *etc.*)
- Containers with lids for purge water (*e.g.,* 5-gallon buckets, drums, tanks)
- Stopwatch, timer, or watch
- Graduated measuring container appropriately sized to measure expected flow rate
- Global Positioning System (GPS)
- Engineer's tape measure (graduated in fractions of feet)
- Drum labels
- Field book and Pumping Test Field Data Records (electronic and hard copy)
- Daily activity log sheets
- Semi-log graph paper
- Calculator
- Conversion tables
- Lint-free, non-abrasive, disposable towels (*e.g.,* Kimwipes®)
- Indelible marking pens, ink-pen, and/or pencil
- Plastic bags (e.g., Ziploc®)
- Teflon® tape
- Electrical tape
- Plastic sheeting or large trash bags
- Umbrella, tent, or equivalent for shading equipment from sunlight or blocking rain
- Overhead lighting and flashlights or lanterns
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- PVC pipe for surface water gauging standpipes
- Peristaltic pump

5.0 PUMPING TEST PLANNING AND DESIGN

Careful attention to detail in the planning and design of a pumping test will ensure smooth execution of the test and the acquisition of reliable data. An understanding of fundamental well hydraulics is necessary for the design so that valid and usable data are obtained. The analyst can then expect to be able to achieve a good fit to the data with the appropriate solution and produce accurate estimates of hydrogeologic properties that are consistent with the conceptual model and well established ranges of values in the literature.

An accurate conceptual model of the site must be developed to assist with the planning, design, and the selection of the proper equipment, wells, and procedures for the test. All available information regarding the site, the geology, and the hydrogeology should be collected and reviewed at the commencement of the pumping test planning phase. Important information includes the following:

- lithology
- depth to aquifer
- aquifer saturated thickness
- aquitard thickness
- locations of aquifer boundaries and/or facies changes
- surface water body locations
- locations of springs
- existing hydraulic property estimates
- data on all site wells and nearby wells (geologic logs, well construction logs, water levels, pumping schedules, maximum yield, *etc*.).

Sources of data include the United States Geological Survey (USGS), the state geological survey, and the state environmental regulatory agency. This information will provide the basis for development of a conceptual model of the site, for the selection of the appropriate solution to analyze the data, and for the test design to be consistent with the solution. Estimates of hydraulic properties, aquifer and aquitard thickness, and aquifer boundaries are used in the design phase to calculate drawdown in the aquifer for a range of pumping rates and parameter values that are consistent with the conceptual model.

Familiarity with the solutions and data inputs to analyze pumping tests (*e.g.,* Duffield, 2007) is critical to identifying potential data needs for the selected solution. It is important that the geometry of the site, the locations and depths of observation wells and piezometers, and the pumping period are appropriate for the solution to be used in the analysis of the data. A pumping test should be designed for the most important parameters relevant to the objectives for the site, potentially at the expense of other parameters that may be derived from pumping tests.

The following American Society for Testing and Materials (ASTM) Standards are available for the planning and design of pumping tests:

1) Standard Test Method for (Field Procedure) for Withdrawal and Injection Well Testing for Determining Hydraulic Properties of Aquifer Systems (D-4050);

2) Standard Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis [and Modified Theis] Nonequilibrium Method (D-4106, D-4105);

3) Standard Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers (D-5270);

4) Standard Test Method (Analytical Procedure) for Determining Hydraulic Properties of a Confined Aquifer and a Leaky Confining Bed with Negligible Storage by the Hantush-Jacob Method (D-6029);

5) Standard Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method (D-5269);

6) Standard Test Method (Analytical Procedure) for Determining Hydraulic Properties of a Confined Aquifer Taking into Consideration Storage of Water in Leaky Confining Beds by Modified Hantush Method (D-6028);

7) Standard Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques (D-4043); and

8) Standard Practice for Design and Installation of Groundwater Monitoring Wells (D-5092).

Some factors for consideration in the planning stage of the pumping test are as follows:

- site access
- communications
- weather
- necessity of a drill rig or winch for lowering and retrieving the pump
- electric power supply or generator and fuel
- whether flowing artesian conditions exist
- groundwater quality/contamination
- water discharge location and permit
- information for existing wells on the site
- availability of driller
- proximity of equipment suppliers
- availability of pump, flow meter, and transducers
- availability of personnel
- reservation of company or rental vehicle
- phone and computer battery charging

All available information about the aquifer and existing wells should be reviewed as part of the planning process. A good practice is to develop a checklist of equipment and preparations.

If data on hydraulic properties are unavailable, and wells in the target aquifer exist at the site, slug tests could be performed to get preliminary estimates of the aquifer hydraulic conductivity. If site wells do not exist, estimates of hydraulic property values could be obtained from literature compilations based on the lithology indicated on borehole geologic logs or from core data and/or publications or drillers' records on the geology of the area. Well logs for water supply wells in the area may be available, potentially with data on short term capacity tests, for estimating hydraulic conductivity. Hydraulic conductivity could be estimated from grain size analyses (*e.g.,* Fetter, 2001), if these data exist, or if samples of the aquifer were obtained for laboratory analysis. Estimates of storage could be based on porosity.

Contacting owners of extraction wells in the vicinity of the site to determine pumping schedules and/or coordinate suspension of pumping for the period of the test, including the pre-test monitoring phase, is essential in the planning stage. If pumping cannot be suspended, a record of the pumping rates and times should be requested.

Flush-mounted wells in paved and/or low-lying areas should have riser extensions installed to prevent inflow of runoff or the inadvertent introduction of dirt or other materials. If riser extensions are not installed, a strong, stable berm should be constructed to prevent inflow of runoff. Similar measures should be considered for wells with flowing artesian conditions (water level rising above ground surface) to ensure proper water level monitoring and prevent water overflow.

Testing in the presence of NAPL requires special precautions and equipment. Personal protection and compatibility of testing and monitoring equipment must be ensured.

5.1 Pumping Test Design

The desired flow rate of a pumping test depends on the purpose of the test. A pumping test to determine hydraulic conductivity for assessing contaminant transport would generally not need as high of a flow rate as a test for a groundwater supply well. However, for an aquifer being investigated for water supply potential, the design of the initial test well and its maximum yield may be based only on the objective of determining aquifer parameters for design of the supply well. Also, the aquifer need not be stressed to the maximum yield of a well in order to obtain good estimates of aquifer properties. If the vertical hydraulic conductivity of an aquitard is being estimated, the flow rate must be sufficient to produce drawdown in the adjacent aquifer.

Pumping tests are designed on the basis of drawdown calculations using the information for the aquifer obtained during the planning stage of the test. A range of hydraulic property values based on this information must be used to bracket drawdown at the pumping well and at various radii from the pumping well considered for observation well locations. The drawdown estimates may be based on a steady-state analytical solution (*e.g.,* Kresic, 1997) and a Theis analytical solution for transient drawdown (*e.g.,* Fetter, 2001), or a numerical solution that implements a three-dimensional conceptualization of the aquifer and boundaries (*e.g.,* MODFLOW). Aqtesolv (Duffield, 2007) has a forward solution wizard for assisting in the design of a pumping test.

5.1.1 Pumping Well and System

Drawdown estimates for the pumping well must include the effects of well inefficiency (head loss attributed to well construction factors and the vertical flow component in an unconfined aquifer contributing to the seepage face in a well). A well efficiency of 70 to 80 percent or more is obtainable, if good well design, construction, and development practices are followed (Driscoll, 1986). The pumping well drawdown estimate, corrected for well efficiency, is obtained by dividing the drawdown estimate from an analytical or numerical solution by no more than 0.8 to account for well inefficiency.

In addition to well efficiency, the drawdown component associated with partial penetration of a well may be significant for thick aquifers and wells with short screens. Drawdown in partially-penetrating wells can be estimated with methods in Aqtesolv or Kruseman and deRidder (2000).

During the design stage of the pumping test, the following factors must be considered for the pumping well: 1) well construction; 2) well development; 3) well access for water level measurements; 4) a reliable power source; 5) the type of pump; 6) the discharge-control and measurement equipment; and 7) the method of water disposal.

<u>Well Construction</u>

The pumping well screen should transect the full saturated thickness of the aquifer, if possible, unless objectives of the test include estimation of the vertical hydraulic conductivity of the aquifer with a solution for partial penetration. The diameter of the well casing and screen must accommodate the pump size required for attaining the objective flow rate. Well design is described in Driscoll (1986).

For a pre-existing well to be used as the pumping well, the total well depth, the borehole diameter, the diameter of the casing and screen, and the depths to the bottom and top of the screen(s) must be known and appropriate for the objectives of the test and the size of the pump required for the flow rate. These data may need field verification, depending on the age of the well and reliability of the information. If the well has more than one screen, only the screen(s) across the aquifer to be tested can be open during the test. Inflatable packers could be used to exclude flow through the other screens.

If the pumping well must be installed, careful geologic logging must be performed during the drilling for the new well to identify the appropriate interval(s) for the well screen(s). Well installation procedures are described in ECR SOP #007, Groundwater Monitoring Well Installation and Driscoll (1986).

<u>Well Development</u>

Newly-installed wells must be developed to achieve maximum well efficiency. If the pumping well is not properly designed, constructed, and developed, the data collected from the well may lead to poor estimates of the aquifer properties. Existing wells may need rehabilitation, potentially including removal of sediments. If the condition of an existing well is unknown, a step-drawdown test may be performed to assess well efficiency. Well development is discussed in ECR SOP #006, Well Development.

<u>Water Level Measurements</u>

The pumping well must have a sounding tube, if water levels will be measured manually. A sounding tube may be installed in the well annulus during well completion or strapped to the discharge pipe during pump installation. If a pressure transducer will be used, it must be greater than 5 feet above the pump intake to avoid effects of turbulence.

Type of Pump

Factors for consideration in the choice of a pump include the well diameter, desired yield, and total dynamic head. Components of the total dynamic head include the lift from the pumping water level to the highest elevation above ground surface where discharge occurs, and all head losses from friction in the discharge pipe, couplings, and valves. Appendices in Driscoll (1986) contain data for estimating friction losses in various types of pipe and fittings. The pump should be able to operate at a rate at least 20% more than the estimated long-term sustainable yield of the well.

Most pumping tests are conducted nowadays with a submersible electric pump, which is recommended for ease of use. Electric pumps can produce the most constant discharge of available pump types. The discharge of gasoline or diesel engine powered pumps is subject to variations in air temperature and barometric pressure, which affect the motor speed, causing up to a 10 percent variation in the discharge rate. However, power line load can vary, causing pumping rate variations in electric pumps. Also, electric motors are nearly constant load devices, and as the lift increases with drawdown, the discharge rate decreases. Good planning and design can minimize the effects of pumping rate variations in electric pumps.

Discharge-control and Measuring Equipment

A valve on the discharge pipe is an effective means of controlling the discharge rate of an electric pump. Rheostat control of the electric pump is a convenient means of regulating the pumping rate. Good estimates of the maximum drawdown and corresponding well yield in the pumping well are essential to maintaining constant discharge for the duration of the pumping test as the drawdown increases. A step-drawdown test is typically performed prior to a constant rate pumping test to determine the optimal rate of pumping. The pump should not be operated at the maximum well yield or the maximum discharge rate of the pump.

Implicit in the control of the discharge rate is an accurate means of measuring the discharge rate. An inline flow meter is the most convenient and typically most accurate means of measurement. However, the discharge rate should always be verified with a timepiece and container of known volume. The size of the container should be commensurate with the discharge rate. For very low discharge rates, less than 5 gallons per minute (gpm), a flow meter may not be necessary. A 5-gallon bucket and watch may be a sufficient means of measuring the discharge rate.

A hydraulic engineer should assist in manifold design to meet the needs of the test and avoid turbulence. For example, some pumping tests (injection) may include the introduction of tracers. Turbulence can be generated by variations in pipe diameter, elbows, valves, a back-pressure gauge, a sample tap, or any other type of port. Sufficient lengths of straight pipe must be installed on the inlet and outlet sides of a flow meter to avoid potential error associated with turbulent flow that may be generated on either side of the meter. A gate valve or butterfly valve upstream of a flow meter can produce as much as 60% error, and the error produced from a partially-closed ball valve can be as much as 50%. Flow meter manufacturers recommend minimum lengths of as much as 30 pipe diameters downstream of control valves and three to four pipe diameters between the meter and downstream pressure taps.

A check valve must be installed at the base of the discharge pipe to prevent backflow of water from the pipe into the well when the pump is shut down during recovery. This measure is necessary to ensure good water level recovery data are obtained

Provide unrestricted flow from the pumping well to water containment. Treatment, if necessary, can be performed prior to discharge. If a flow bypass is installed, do not pump directly through bag filters or any other system that will restrict flow and generate back-pressure on the pump.

If pumped water must be stored in containers, extra tank capacity should be planned for unanticipated circumstances. Use of multiple containers may require a transfer pump to avoid suspension of pumping.

Discharging the water near the pumping and observation wells is typically a poor practice, especially for a test of a permeable unconfined aquifer or fractured rock. The produced water may reach the saturated zone during the pumping and recovery period, affecting test results. A temporary pipeline or hose can be used to transport the water a sufficient distance in the down-gradient direction of groundwater flow, where infiltration would not occur within the cone of depression or affect observations within the radius of influence during the test. The distance may be based on the design-phase drawdown calculations and a map of potentiometry or analyses with MODFLOW or analytic element methods that account for the natural groundwater gradient. Discharge alternatives include a storm sewer, a lined pond, or storage tanks. Permits may be necessary.

Reliable Power Source

Investigate the source of power. A source of uninterrupted power to the electric pump is indispensable. If power failure occurs, the test data may be invalid, and a repeat test may be necessary after water level recovery, a costly outcome. Many pumps cannot utilize power with ground fault circuit interrupter (GFCI) protection. GFCI protection is not always at the outlet. It may be installed at the distribution panel. A generator may be required if the circuit has GFCI protection.

In remote areas, a generator may be necessary. Indeed, use of a generator can avoid current fluctuations that are one source of pumping rate variations. The generator must be reliable and compatible with the pump. Pump compatibility is commonly overlooked in the planning stage. A backup generator is advisable for long-term tests. Fuel consumption of the generator must be known. Sufficient fuel must be stored at the site.

Method of Waste Disposal

If the groundwater is contaminated, special considerations and permits apply. The test designer should review applicable requirements of the RCRA hazardous waste program, the underground injection control program, and the surface water discharge program. It may be necessary to obtain permits for on-site storage, treatment, and disposal of the water.

5.1.2 Observation Wells

Drawdown data may be obtained from both the pumping well and appropriately located and screened observation wells. The number and locations of observation wells depend on the test objectives and conceptual model of the aquifer.

In a confined aquifer, transmissivity is more important than storativity, and observation wells are not necessarily needed. Late time data from the pumping well are typically linear on a semi-log time-drawdown plot (unless boundaries and/or heterogeneities occur). The effects of well losses are irrelevant with a straight-line solution of this portion of the drawdown data, and a good transmissivity estimate of the aquifer in the vicinity of the pumping well can be obtained with the Cooper-Jacob method (Driscoll, 1986). Storage is much larger and more important in an unconfined aquifer. Data from an observation well are required for an accurate estimate of the storage coefficient, which for some solutions is indispensable for the correct estimation of transmissivity (if late time data from a pumping well in an unconfined aquifer are linear, a good estimate of transmissivity can be obtained with the Cooper-Jacob method).

Existing wells are commonly used as observation wells, but the locations and screened intervals may not be appropriate to provide data for use in the analysis of hydraulic properties. However, these wells may be useful for assessing influence and capture, if applicable. Field verification of completion information may be necessary for old wells, if the reliability of these data is questionable. Furthermore, field testing should be performed to verify suitability for monitoring aquifer response. A simple response test consisting of adding or removing a known volume of water and observing the changing water level could suggest screen fouling, if the response is inconsistent with the conceptual model of the aquifer. Wells with poor response should be re-developed, replaced, or omitted from consideration as observation wells.

The distance of observation wells from the pumping well depends partly on the length of the test, the pumping rate, and the anticipated aquifer transmissivity. The distance should not be so great that the pumping test duration is excessive in order to produce sufficient drawdown for analysis. Small measurement errors may be a significant percentage of the total drawdown in distant observation wells.

If an observation well must be installed, it should be located close to the pumping well and constructed specifically for the test. Unless determination of vertical hydraulic conductivity is an important objective, the distance should not be so close where vertical gradients distort the flow field, especially if the pumping well partially penetrates the aquifer.

The selection of the location of a single observation well is critical. In general, an observation well for an unconfined aquifer should be closer to the pumping well than an observation well for a confined aquifer. Many textbooks provide ranges of generally acceptable distances of observation wells for unconfined and confined aquifers that should only be used as guidelines for planning and design. For example:

- Delleur (1999) states that observation wells at distances between 10 meters (m) (33 ft) and 100 m (330 ft) from the pumping well usually provide reliable data, but that the distance for thick or stratified confined aquifers must be greater, from 100 m (330 ft) to more than 250 m (820 ft).
- Driscoll (1986) states that observation wells in unconfined aquifers should be located no farther than 100 to 300 ft from the pumping well, and that observation wells in thick,

considerably stratified confined aquifers should be placed within 300 to 700 ft of the pumping well.

These generalities are not a substitute for good design modeling calculations based on the specifics of the aquifer and objectives of the test (these distances do not apply to low yield and limited aquifers or short duration tests).

The single observation well should be located such that the time-drawdown data collected during the planned pumping period fall on a type-curve of pronounced and unique curvature, especially for an unconfined aquifer. The selection of the location is based on the design-phase transient drawdown calculations. Time-drawdown curves for several hypothetical observation wells at various radii from the pumping well are plotted to assist with the selection. The time of the onset of linear data on a semi-log time-drawdown plot may be considered in the analysis.

Special consideration may be given for the location of a single observation well in a confined aquifer due to the greater importance ascribed to the transmissivity than the storativity. It is desirable to have the location of the observation well within the vertical cylinder around the pumping well that serves as the conduit for flow to the well. The radius (R) of this zone is estimated with the following equation:

$R = (0.2(Tt/S))^{0.5}$

in which:

T is transmissivity (L^2/t),
t is time, and
S is Storativity (dimensionless)

This zone does not contribute water from aquifer storage after the time used in the calculation, and the change in drawdown is independent of this zone. This configuration results in optimal data for use of the Cooper-Jacob straight-line solution to estimate transmissivity using a semi-log plot of log time vs drawdown. This estimate is then used in a more sophisticated solution for determination of the storage coefficient.

If an aquifer is believed to be extensive and homogeneous, a single observation well would suffice to provide data for determination of the storage coefficient, as well as the transmissivity. Additional observation wells at varying distances from the pumping well would permit comparison of results from different time-drawdown analyses to evaluate heterogeneity. A distance-drawdown analysis may be applicable. Placement of observation wells in different directions and distances would be advisable for evaluation of heterogeneity, recharge or barrier boundaries, and potential horizontal anisotropy. Use of an observation well in a vertically-adjacent aquifer separated by an aquitard provides data for evaluating leakage and for determining the vertical hydraulic conductivity of the confining layer. If the pumping well is partially penetrating the aquifer, an observation well can also be optimally located and screened for estimating the vertical hydraulic conductivity of the aquifer due to vertical gradients near the pumping well.

If two observation wells are planned, they should be in a radial line extending from the pumping well. Fetter (2001) states that the second observation well should be located at 10 times the distance of the close observation well, but this criterion must not be accepted without design modeling calculations. If more than two observation wells are used, they should form two or more radial lines extending from the pumping well, unless the objective includes evaluation of radial heterogeneity or use of the distance-drawdown method of analysis. If a boundary is known or suspected, an observation well should be placed in the direction of the boundary. If the principal directions of anisotropy are known, drawdown data from two wells located in these directions from the pumping well will be sufficient. If the principal directions of anisotropy are unknown, at least three wells in different directions are needed.

Most observation wells are constructed with screens 3 to 6 feet long. Longer screens may be desirable, depending on the amount of stratification, but are generally not absolutely necessary (Driscoll, 1986). Screens for observation wells in the aquifer being tested should be installed across approximately the same stratigraphic interval as the central portion of the screen in the pumping well. Geologic logs must be reviewed, if structural dip and/or ground surface elevations are factors in observation well screening depth. The same stratigraphic interval is very important, if the pumping well has a short screen and/or is not screened across the full thickness of the aquifer, because strong vertical gradients in head develop near the top and bottom of the partially-penetrating pumping well screen, and flow to the well is not horizontal. Vertical to horizontal anisotropy in hydraulic conductivity ($K_v/K_h < 1$) also plays a role in the distortion of the flow field.

If a partially-penetrating observation well in a confined aquifer of thickness b is located further than a distance of $R = 1.5b(K_h/K_v)^{0.5}$ from the partially-penetrating pumping well, the effect of the partially-penetrating pumping well is negligible. If the observation well is within the zone of distorted flow, but completely penetrates the aquifer, the effect of the partially-penetrating pumping well is also negligible. Conversely, locating a partially-penetrating observation well within the zone of distorted flow provides data for estimating the vertical hydraulic conductivity of the confined aquifer. If data are also obtained from a more distant observation well, the horizontal hydraulic conductivity estimate from these data would constrain the estimate of vertical hydraulic conductivity from the close well data.

The effects of partial penetration of a pumping well in an unconfined aquifer are also minimized, if the observation well fully penetrates the saturated thickness of the aquifer. Under these screening conditions, the time-drawdown data for the observation well located at a distance greater than $R = b/(K_v/K_h)^{0.5}$ and for times greater than $t = S_yR^2/T$ will follow the late-time Theis curve. The time-drawdown data for an observation well located at a distance less than $R = 0.03b/(K_v/K_h)^{0.5}$ and for times less than $t = SR^2/T$ will follow the early-time Theis curve. Intermediate-distance observation wells are useless for the analysis of aquifer properties from a test performed with a partially-penetrating pumping well in an unconfined aquifer (Fetter, 2001).

The diameter of observation wells should be just large enough to permit access with a sounder for accurate and rapid measurement of the water levels or for installation of a transducer. Small diameter wells (*i.e.,* 2-inch diameter) are preferred, because the volume of water contained in a large diameter observation well may cause a time lag in the drawdown response of the aquifer. However, small diameter wells may be difficult to develop, which is an important consideration in the test design.

6.0 PUMPING TEST PROCEDURES

A pumping test consists of four components: 1) pre-test (baseline) water level monitoring; 2) a step-drawdown test; 3) a constant rate (drawdown) test; and 4) water level recovery monitoring.

6.1 Baseline Monitoring Phase

Good records of baseline groundwater levels within the pumping well(s), observation wells, and key wells adjacent to the site are vital to achieving accurate pumping test results. Pressure transducers should be installed in the wells for continuous recording of water levels for a week before the start of the step-drawdown test. Use the same type of transducer (*i.e.,* vented/gauge or total pressure) in all wells with appropriate ranges for expected drawdown (see Section 4.0). Transducers should be tested prior to deployment. A barometer should also be deployed for recording throughout the baseline, drawdown, and recovery periods, and for at least a day to a week after completion of the recovery measurements. The barometer should be centrally located among the wells. If there are significant elevation differences among well locations, more than one barometer may be necessary to avoid over- and/or under-compensation of the water level data. Baseline and barometric data are used to establish ambient water level trends for drawdown corrections and to calculate barometric efficiency (use of vented/gauge transducers does not obviate recording barometric pressure for potential barometric efficiency corrections). Baseline data may also show water level fluctuations that reflect known or unknown nearby pumping, for which pumping rate and schedule data may be important in the analysis of the aquifer test data. If possible, the cooperation of nearby well owners should be secured to either cease pumping or to control and document the discharge of these wells during the baseline, testing, and recovery periods. In some settings, significant diurnal effects of evapotranspiration may be evident in the baseline water level data. The objective of baseline data collection is to model all influences on test and recovery period water levels that are unrelated to the pumping well discharge.

Precipitation data must also be obtained for the baseline, testing, and recovery periods to evaluate potential recharge effects on water levels. An onsite rainfall gauge is advised. Significant precipitation during testing and/or recovery may invalidate portions or all of the data for the analysis of hydraulic parameters. Surface water gauging standpipes equipped with transducers in nearby water bodies may be important for evaluation of potential tidal fluctuations and recharge effects on aquifer water levels.

6.2 Step-Drawdown Test

Prior to conducting the constant-rate test, a short-duration, step-drawdown test should be performed to determine a sustainable pumping rate for the constant-rate test. The test provides data on the relationship between the pumping rate and drawdown, partly as a function of well efficiency.

A step-drawdown test involves pumping the well at a series of pre-defined, successively increasing, equal duration constant rates and continuously recording drawdown in the pumped well and, optionally, observation wells with a pressure transducer. The duration of each step is thirty minutes to two hours to provide sufficient time for the potential and desired stabilization of the pumping water level. The number (and duration) of steps is at the discretion of the investigator and/or dependent on budget. One factor that may influence the choice in the number of steps is the desired accuracy in determination of the maximum pumping rate. A test with only a few steps may have a large increment in the pumping rate that bounds the maximum rate by a large interval. The maximum rate is typically unknown, but may be estimated with calculations. The maximum rate corresponds to the maximum available drawdown. The maximum rate is estimated on the basis of analytical or numerical calculations using an estimate of the hydraulic conductivity of the aquifer, well construction specifications, and an assumption of 70 to 80 percent well efficiency.

A potential scheme for defining the rates for each step is to divide the calculation-estimated maximum pumping rate by a chosen number of steps, with the provision to exceed the estimated maximum rate. For example, the first step is conducted at a rate corresponding to approximately 25 percent of a calculation-estimated maximum pumping rate. The pumping rates for successive steps correspond to approximately 50, 75, 100, and 120 percent of the estimated maximum pumping rate.

Rates and times of pumping should be recorded for potential analysis of the data, including the recovery data, for aquifer properties. Pumping rates should be frequently monitored with the intent to hold the rate for each step constant.

The water level recording time interval of the data logger is dependent on the objectives of the test. If aquifer parameters are to be estimated from the data, and a storage coefficient is important, then early time drawdown and recovery data should be acquired at an interval no greater than 30 seconds for at least 3 to 5 minutes (See USEPA, 1993 for recommended time intervals of water level recording).

After the pump is shut off at the completion of the step-drawdown test and prior to beginning the constant-rate test, the water level in the pumping well should recover to the static water level or at least 95 percent of the drawdown at the end of the test. During this recovery period, the step-drawdown data are evaluated to determine the maximum sustainable pumping rate of the well.

A step-drawdown test may also be conducted to estimate the long-term yield of a well and may be used to develop performance specifications for the selection of future permanent pumping equipment. The step-drawdown test does not provide an accurate assessment of well efficiency, for which a constant-rate test is necessary *(e.g.,* Driscoll, 1986).

6.3 Constant-Rate Test (Drawdown Phase)

The constant-rate test is conducted with a sustainable pumping rate at or lower than the maximum sustainable rate determined from the step-drawdown test. The duration of the test is dependent on the project objectives, properties of the aquifer, location of suspected boundaries, desired accuracy of the storage coefficient and transmissivity, and rate of pumping. A duration of one to three days is desirable. A simple criterion for sufficient duration of pumping is the elapsed time corresponding to a well-developed linear trend of the time-drawdown data on a semi-log plot for the most distant observation well. However, a linear trend can also result from interception of the drawdown cone with a boundary.

Periodic downloads and plotting of the transducer data are advisable for checking instrument functionality and the shape of the time-drawdown curve. Pumping should continue until the time-drawdown data adequately define the shape of the type curve intended for analysis. This objective may require pumping for a significant period after the rate of water level change becomes small (water level stabilization). If applicable, extended pumping may be particularly relevant for seeing the effects of boundaries or delayed drainage in the data. Boundary effects may occur a few hours after pumping starts, or after days or weeks. If a hydrologic boundary (e.g., river) is encountered, there may be no additional drawdown and no reason to continue pumping. Drawdown calculations from the design phase of the pumping test can be used as a guideline for the required test duration and assist with interpretation of the field data.

After the pump is started, the desired discharge rate should be attained rapidly. Frequent, diligent monitoring of the pumping rate is essential, with importance placed on maintaining the rate constant. The discharge rate should not vary more than a few percent. The rate decreases with increasing drawdown and may suddenly change with interception of a boundary or heterogeneity in the aquifer. The water level in the pumping well must also be checked frequently to ensure drawdown does not reach the pump. The work plan should include instructions for field crew in case these circumstances arise. For example, if unanticipated drawdown occurs and a constant rate cannot be maintained for the planned test duration, then termination of pumping may be warranted, followed by collection of recovery data, or reduction of the rate for the duration of the pumping period. All significant rate variations and times associated with unanticipated drawdown must be recorded.

Pumping rates and times corresponding to the rates must be carefully recorded for analysis of the data. This requirement is commonly overlooked under the misconception that rate variations are irrelevant in the analysis of the recovery data.

The data loggers should be start-time synchronized (and synchronized with other time-recording devices) and all configured to record pressure readings at the same logging interval. If a logarithmic or other programmable increase in the logging interval is used, it is even more critical to synchronize the start and stop times of the data loggers. The initial time interval for the first three to five minutes of drawdown and recovery should be no more than 30 seconds (See USEPA, 1993 for recommended time intervals of water level recording). The duration of the pumping test must be considered for configuring the recording intervals to ensure sufficient data storage capacity. Excessively large transducer data sets associated with short duration pumping tests are unwarranted. For example, the data logger may be able to store data in one second intervals for a 24 hour test, but processing can be cumbersome, and the analysis does not require that frequency.

6.4 Water Level Recovery Phase

Water level recovery monitoring begins immediately after cessation of pumping. If a non-constant logging interval was used for the pumping period, data loggers must be synchronously reset at the time pumping ceases to record at the same logging intervals used for the pumping period or some other logging interval common among all data loggers. The recovery period should be a minimum of 8 hours, or until water levels recover 90 percent of the maximum drawdown.

6.5 General Guidance and Precautions

(a) Prior to accessing a well, the wellhead should be assessed for conditions that might be hazardous or result in the introduction of debris and/or water into the well. Rodents and insects (e.g., bees, wasps) may have constructed nests within the protective casing of a well.

Flush-mounted wells may have water or road sand/salt/debris inside the curb box. If insects are encountered, insecticides should be used with caution to avoid introduction of chemicals to the well. If surface water, debris, or chemicals are introduced into the well, the Project Manager should be notified immediately.

(b) If a flush-mounted well is compromised by runoff during the test, a peristaltic pump may be used to drain the curb box. If there is risk of water entering the well, it should be sealed with the expansion plug.

(c) Bolt cutters may be necessary to remove rust-frozen locks. However, try dipping rusted locks in a soapy solution. Use of oils and other products containing VOCs (e.g., WD-40) should be avoided to prevent contamination of the well. Replace rusty locks.

(d) The pump should be equipped with a check valve to prevent water in the discharge piping from re-entering the well during recovery.

(e) Prior to installation of a submersible pump in a well, ensure that the tubing is securely fastened to the pump. A cable must be attached to the pump for installation and removal. Never lower a pump into a well using only the tubing.

(f) The pump should be set above or below the screen, if possible, to avoid potential deleterious effects of distorted flow patterns in the vicinity of the screen, including sand pumping (Driscoll, 1986).

(g) A submersible pump should not be lowered to the bottom of a well to avoid getting the pump stuck in potentially accumulated fine-grained sediment.

(h) Pumping rates should be measured with an in-line flow meter, or if appropriate for low rates, by recording the time to fill a bucket of known volume. Prior to initiating pumping, be familiar with the means of controlling the pumping rate.

(i) Test the circuits. A separate circuit for the pump is advised. If only a single circuit is available, test the circuit with the full load of all equipment operating simultaneously. If there is any question that the circuit may be unable to maintain the load, then a generator must be used.

(j) Lockout/Tagout procedures must be implemented for the power supply, with the pumping circuit clearly labeled.

(k) Ensure there is an adequate supply of fuel for the generator. Check the fuel level routinely during the test.

(l) If pumped water must be stored in containers, conservatively estimate the amount of water that will be generated and arrange for proper storage and disposal according to applicable regulations and the project-specific work plan.

(m) Carefully inspect storage tanks or other containment systems for potential leaks prior to initiating the testing.

(n) The transducers must be securely anchored at the wellhead to prevent unintentional change in depth and must not be moved after the initial depth setting for the pre-test water level monitoring. Do not permit groundwater sampling during the testing.

(o) Calibrate the transducers before the test. Throughout the testing, take periodic manual water level measurements with an electronic water level meter to verify performance and accuracy of pressure transducers. Have extra batteries for the electronic water level meter.

(p) If total pressure transducers (*e.g.,* Divers) are deployed, at least two barodivers should be recording barometric pressure, in case one device fails.

(q) Use of two pressure transducers is advised for the pumping well, in case one fails.

(r) If a logarithmic or other programmable increase in the logging interval is used for recording during any observation phase, the data loggers must be synchronously reset for the next phase (*e.g.*, pumping to recovery). Otherwise, an inappropriately long recording interval would be used for the start of the next phase, in addition to the potential for insufficient storage capacity.

(s) Avoid beginning a pumping test that may be subjected to adverse weather conditions by checking the forecast. Air temperatures below 32°F may cause ice to form in the discharge tubing and the in-line flow meter. Heavy rain could generate undesirable recharge and/or result in runoff entering flush-mounted wells. Be prepared to cover electronic equipment that could be impacted by rain. Also be prepared to prevent potential blowing dust from entering wells.

(t) Avoid the potential for cross-contamination among wells. Decontaminate the electronic water level meter after each usage.

(u) All field observations and comments, including discharge rates and times, manual water level measurements and times, and weather should be recorded on an appropriate field form (Attachment A). In addition, the Site Name and/or ID, the service company performing the pumping test, the dates and times of starting and stopping the pump, static water levels from top of casing, depths of transducers from top of casing, water level and flow rate measurement instruments, and pump type should be recorded on a form. For each monitoring location, record the Well ID, location, and distance from pumped well or GPS readings for all wells.

7.0 DECONTAMINATION

All pumping and monitoring equipment should be cleaned using a triple rinse decontamination process. The equipment should first be scrubbed in a Liquinox solution, followed by a deionized water rinse, and then a final rinse with deionized water. The equipment will then be given time to air dry, or wiped dry with paper towels.

8.0 INVESTIGATION-DERIVED WASTE DISPOSAL

A plan must be developed prior to field work for disposal of investigation-derived waste (IDW). Recovered groundwater and other wastes produced during the testing should be handled, containerized, labelled, stored, and transported in accordance with the HASP, hazard communication plan, and state and Department of Transportation (DOT) requirements. Field personnel should be familiar with the project-specific requirements for IDW.

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10.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	DECEMBER 2016	NOT APPLICABLE

Attachment A:

Example Pumping Test Field Data Records

Page ____ of ____

Pumping Well Aquifer Test Form

WELL NO. ____________

Project Name and Location	GPS Coordinates	Project No.

TEST TYPE (select one):
Constant Rate ____________
Step Test ____________

DATE/TIME:
Start Date/Time ____________
Finish Date/Time ____________

WELL CONSTRUCTION: Measuring Point ____________
Borehole and Casing Dia. (in) ________ Total Depth (fbg) ____________ Screen Interval (fbg) ____________ Static Water Level ____________ Date/Time

PUMP INFORMATION:
Type ____________ Make ____________ Diameter ____________ Installation Depth ____________

WATER LEVEL DEVICE:
Meter Type ____________ Transducer Type ____________ Transducer Depth ____________ Measuring Point ____________

WEATHER CONDITIONS: General notes ____________
Source of Barometric and Precipation Data ____________

General Information: | Field Staff:

Date	Time	Elapsed Pumping Time (min)	Depth to Water (feet)	Drawdown or Residual Drawdown (feet)	Pumping Rate (gpm)	Totalizer Reading (gal)	REMARKS

Page _____ of _____

Observation Well Aquifer Test Form

WELL NO. ______________________

Project Name and Location	GPS Coordinates	Project No.

TEST TYPE (select one):
Constant Rate __________
Step Test __________

DATE/TIME:
Start Date/Time: __________
Finish Date/Time: __________

WELL CONSTRUCTION: Measuring Point __________ Distance from Pumping Well __________
Borehole and Casing Dia. (in) ________ Total Depth (fbg) __________ Screen Interval (fbg) __________ Static Water Level __________ Date/Time

WATER LEVEL DEVICE:
Meter Type __________ Transducer Type ______ Transducer Depth __________ Measuring Point __________

WEATHER CONDITIONS:
General notes ______________________________
Source of Barometric and Precipitation Data: ______________________________

General Information:
Field Staff:

		PUMPING			RECOVERY			
Date	Time	Elapsed Pumping Time (min)	Depth to Water (feet)	Drawdown (feet)	Elapsed Pumping Time (min)	Depth to Water (feet)	Residual Drawdown (feet)	REMARKS

Title: **Slug Test Procedures**	Procedure Number: **ECR 029**
	Revision Number: **0**
	Effective Date: **February 2019**

Authorization Signatures

Jeff Hansen Principal Author	Date 2/15/19	David Hay Contributing Author	Date 2/15/19
Nidal Rabah Technical Reviewer	Date 2/15/19	Elizabeth Denly ECR Practice Quality Coordinator	Date 2/15/19

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1.0 INTRODUCTION

1.1 Scope and Applicability

The objective of this Standard Operating Procedure (SOP) is to specify the methodologies and techniques for performing slug tests to estimate local aquifer properties. The parameters obtained from a slug test analysis represent the saturated medium in the immediate vicinity of the well screen due to the limited volume of the displaced groundwater and the heterogeneity of geologic media.

1.2 Summary of Method

Slug tests are performed by near-instantaneous raising or lowering the water level in a well, then measuring the change in water level with time as it rebounds to the static water level. The most common and preferred method for initiating a slug test is to rapidly introduce or remove a solid object to/from the well. In low permeability media, it is possible to measure the change in water level using an electronic water level indicator. However, it is preferable to use a pressure transducer and a data logger during slug tests for frequent water level measurements, particularly during the early part of the test when the rate of water level rebound is greatest. These early time data are essential for differentiating filter pack drainage effects from aquifer response (*i.e.,* groundwater flow from or to the aquifer), which is required to calculate hydraulic conductivity.

Recorded measurements of transient water level rebound are analyzed for aquifer parameters using analytical solutions that account for well geometry (*i.e.,* well casing radius, borehole radius, and length of screen or open borehole), hydrogeologic boundary conditions (*e.g.,* aquitard thickness for leaky aquifers and block thickness/diameter in bedrock aquifers), and other hydrogeologic information (*e.g.,* water level displacement, initial static water column height, depth to the top of the screen below the top of the aquifer, and aquifer thickness). The solutions vary depending on the type of aquifer (confined or unconfined), boundary conditions, partial or full aquifer penetration, and the potential occurrence of wellbore skin and inertial effects. *The Design, Performance, and Analysis of Slug Tests* (Butler, 1998) is an essential reference for project managers, field personnel, and data analysts.

1.3 Equipment

The following equipment is generally needed for performing slug tests:

- Well keys and/or gate box key
- Hand tools, including socket set and safety knife
- Three- to five-inch long bolt to hang slug from the well head
- Health and safety monitoring equipment – consult health and safety plan (HASP)
- Trash bags
- Buckets (5-gallon capacity)
- Electronic water level meter and/or oil/water interface probe

- Gauge/Vented transducer and data logger. If a non-vented (absolute pressure) transducer is used, a barometer should be deployed during testing to assess barometric pressure effects. Applying barometric pressure corrections prior to data analysis is especially important for slow rebounding water levels in low permeability media.
- Polyvinyl chloride (PVC) slugs (two different displacement volumes varying by a factor of two or more), or, for very high hydraulic conductivity media, an air-tight pneumatic well-head apparatus with compressed air or nitrogen gas supply, regulator, and appropriate fittings. Pneumatic well-head apparatus configurations may vary by manufacturer. The user should check with the manufacturer to determine specific types and diameters of fittings needed to connect the compressed gas supply to the well-head apparatus and to secure the apparatus to the well casing.
- If slug test is conducted by water removal
    - A bailer or a pump (and hoses, pipes, or tubes with necessary fittings)
    - Containers and check valves and gages
- Compressed air or nitrogen
- Duct tape
- 1/8-inch nylon rope or similar
- Polyethylene sheeting
- Laptop computer or tablet with appropriate software for downloading data
- Site documents: HASP, Field Sampling Plan (FSP), SOP, site plan, access agreements, etc.
- Test well construction data including diameter, depth, screen interval, etc.
- Field logbook, pen, permanent marker, data sheets, etc.
- Personal Protective Equipment (PPE) - see site-specific HASP
- Air monitoring equipment as required by the HASP (*e.g.,* photoionization detector (PID), flame ionization detector (FID), multi-gas meter, dust meter, etc.)
- Traffic control/warning equipment (cone, tape, etc.)
- Decontamination equipment (*e.g.,* Alconox®, Liquinox®, or equivalent, distilled water, paper towels, spray bottles, and brushes, as needed).

1.4 Definitions

Falling Head Test – A slug test which rapidly raises the water level in a well, followed by recording the transient water levels and times since initiation of the test until the level rebounds to or closely approaches the static water level.

Hydraulic Conductivity – A property of porous or fractured media that defines the rate of fluid flow through the media. In the English System of measurement, the typical units of hydraulic conductivity are gallons per day per square foot (gal/day/ft^2), or feet per day (ft/day). In the International System (SI), the units are meters per day (m/day) or centimeters per second (cm/sec).

Rising Head Test – A slug test which rapidly lowers the water level in a well, followed by recording the transient water levels and times since initiation of the test until the level rebounds to or closely approaches the static water level.

Slug – A solid object, volume of water, or pressurized air or nitrogen that induces a sudden change of head in a well. The change in water level may be induced by adding a known volume of water to a well (usually with a drop tube) or removing water using a bailer or pump, although techniques involving addition or removal of water should be avoided (Butler, 1998).

When a solid object is used to initiate the water level displacement, a slug is commonly a cylindrical object that can be submerged in the well water or withdrawn from the water to generate the displacement. The advantage of using a solid slug is the capability of properly conducting slug testing by performing a series of alternating rising and falling head tests. The solid slug is commonly constructed with an appropriate diameter and length of PVC pipe that is filled with clean sand and securely capped and sealed at both ends. An eye bolt is fastened to the top of the slug for attaching cotton twine or a rope (nylon or polypropylene) to enable lowering or raising the slug in the well. Natural fiber ropes may be treated with oil and should not be used. A slug should have the capability of generating an initial displacement of the water column in the test well ranging between 0.5 foot and 3 feet, depending upon the permeability of the medium (Cunningham, 2010). Water level displacements at the lower end of this range are preferable in low permeability media to minimize the rebound time, especially for conducting multiple tests in a well and testing multiple wells. Displacements toward the upper end of the range are generally better suited for higher permeability media, in which the rebound time is faster.

Well Skin – A finite thickness zone of altered natural permeability near the wellbore, which is classified as positive or negative according to whether the skin has lower or higher permeability than the natural medium. In the case of a positive skin, the medium near the wellbore has a decreased permeability, which may be the product of many factors, including drilling mud infiltration, fine sediments distributed along the borehole wall during drilling, or mineral precipitation. A negative skin occurs when the permeability immediately adjacent to the wellbore is enhanced by processes such as washing out natural fractures or solution cavities near the wellbore, hydraulic fracturing, or acid treatment during well development or rehabilitation.

2.0 PERSONNEL QUALIFICATIONS

Since this SOP will be implemented at sites or in work areas that may entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers and 8-hour annual HAZWOPER refresher training.
- OSHA 10-hour Construction Industry Outreach Training.
- Site-specific safety training.

2.1 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. TRC personnel will use appropriate PPE. The Project Manager, Office Safety Coordinator (OSC), TRC ECR Safety Manager, or TRC

National Safety Director can address questions or safety concerns. Project-specific safety considerations should be documented in the project-specific work plan (or equivalent).

If the HASP indicates that groundwater in the wells may contain measurable levels of volatile organic compounds (VOCs), the wellheads should be screened using a PID or FID to assess the VOC vapor level and identify the necessary procedures. If monitoring results indicate elevated VOC concentrations in the well, the level of PPE may need to be increased in accordance with the HASP. Contact with non-aqueous phase liquid (NAPL), if present, should be avoided.

For safety and avoidance of error associated with fatigue, a work shift should be no longer than 12 hours. A minimum break time of 8 hours following a work shift is recommended.

3.0 PLANNING FOR SLUG TESTING

The planning stage for slug testing includes compiling well construction data (*i.e.,* well diameter, borehole diameter, screen length, total well depth) and hydrogeologic information (water levels and a description of the media screened by the wells). These data will be used to select and/or implement the appropriate equipment, including the transducer, the slug type and size, and the rope length for a solid slug. An initial estimate of the magnitude of hydraulic conductivity will assist in the choice of slug type and size based on expected duration of rebound and number of wells.

Information on well development and the age of the well should be reviewed to determine if additional development is warranted prior to testing. Well development is typically minimal at monitoring wells (Butler, 1998). If new wells are being installed, consider designing them to minimize the thickness of the filter pack annulus to limit filter pack drainage and the length of screen for efficiency of well development.

3.1 Cautions & Potential Problems

(a) Slug tests in wells constructed with 1) large annulus filter packs relative to the radius of the well casing and 2) filter packs extending several feet above the top of the well screen may produce water level rebound data that are significantly compromised by filter pack drainage. Careful evaluation of slug test data generated from these wells should be performed by a hydrogeologist or engineer experienced in slug test analysis to determine if the resulting aquifer parameters are consistent with the geologic medium.

(b) Transducers are rated for a range of pressures. When using a transducer, verify that the transducer is rated for the pressure head that will be encountered in the well during the test. For example, a transducer rated at 30 psi would be appropriate for use at depths of up to 69 feet below the static water level ([2.31 feet of water column/1 psi] * 30 psi = 69 feet). Note that when conducting slug tests, transducers need not be installed at depths greater than 10 feet below the base of the slug when fully immersed. Therefore, transducers rated for pressures of 10 to 20 psi are adequate.

(c) Prior to initiating the test, the transducer should be set a minimum of one foot above the bottom of the well, and the transducer cable shall be secured at the top of the well to prevent vertical movement of the transducer during the test. The transducer must also be located sufficiently below the bottom of the fully immersed solid slug, several feet if possible, to avoid producing dynamic pressure effects in the data.

(d) When using transducers and data loggers, data should be collected at an appropriate rate. A rapid rate is important in high permeability media, where water level rebound is rapid and filter pack drainage must be distinguished from aquifer discharge during data analysis.

(e) Solid slugs should have a diameter that does not impede the flow of water along the slug or into or out of the well.

(f) If a solid slug is used to initiate a test, ensure there is sufficient space for the slug and the transducer cable to avoid disturbing the transducer during insertion or withdrawal of the slug.

(g) Although not a recommended method of slug testing, if rising head tests are performed with a bailer, the bailer should be completely removed from the well.

(h) In order to obtain accurate aquifer parameters, wells must be adequately developed to remove drilling debris along the borehole wall and drilling additives (if used) that may form a low permeability "skin". In wells screened across the water table, some development of the unsaturated filter pack is desirable to ensure that aquifer response data collected during falling head tests are representative of the aquifer. In cases where the extent of well development is questionable, redevelopment of the well prior to slug testing should be considered.[1]

(i) A minimum of three slug tests should be performed at each well. The magnitude of the initial displacement should be varied by at least a factor of two, and the first and last tests of the series should have the same initial displacement. The direction of slug-induced flow should be varied during the series of tests to identify a skin-related directional dependence. The flow direction in the majority of tests should be from the medium into the well (rising head test). Flow from the well into the medium (falling head test) can lead to a progressive decrease in near-well hydraulic conductivity as a result of mobilized fine material being lodged deeper into the medium. Data from slug tests with two different slug sizes and different flow directions can be used to assess the occurrence of a well skin.

(j) A good approach to slug testing is to initiate the series of tests with a rising head test. Slowly submerge the slug, then wait for the water level to return to static. Perform at least the following tests: the initial rising head test, followed by a falling head test, and finishing with a rising head test.

(k) An ideal test series consists of the initial rising head test followed by a pair of falling head and rising head tests with a larger slug and finishing with a pair of falling and rising head tests with the smaller slug.

[1] It may be appropriate to perform slug tests on a well before redevelopment to assess the need for redevelopment. For example, if a change in hydraulic conductivity from baseline conditions is suspected, that would be related to injection of remedial amendments.

4.0 PROCEDURES FOR SLUG TESTING

4.1 Slug Tests Using Solid Slugs and Bailers

The following procedure is recommended for slug testing:

(a) Prior to conducting slug tests, the expected initial water level displacement (H_0*) in the well should be calculated for each slug and recorded on a field form or in a field book. Water level displacement by solid slugs and bailers is calculated with the following equations:

$$V_s = p * r_s^2 * h_s = V_{sw} = p * r_c^2 * h_c$$

or

$$h_c = (r_s^2 * h_s)/r_c^2 = H_0*$$

Where:

V_s = volume of the slug (L^3),
p = 3.1416,
r_s = radius of the slug (L),
h_s = length of the slug (L),
V_{sw} = volume of water displaced by the slug (L3),
r_c = radius of the casing/screen (L), and
h_c = water level displacement in casing/screen (L).

The actual water level displacement (H_0) is less than H_0* because the slug does not displace the water in the casing/screen instantaneously, and drainage from the filter pack begins before the slug is completely withdrawn (rising head test), or some of the displaced water enters the unsaturated filter pack before the slug is fully submerged (falling head test). H_0* can be bounded at the lower end by accounting for the filter pack porosity and assuming no flow to or from the medium:

$$V_{sw} = p * r_s^2 * h_s = p * r_c^2 * H_{0L*} + (p * r_w^2 * H_{0L*} - p * r_c^2 * H_{0L*}) * f_{fp},$$

or

$$H_{0L*} = r_s^2 * h_s / [r_c^2 + f_{fp} * (r_w^2 - r_c^2)]$$

Where:

H_{0L*} = minimum expected initial water level displacement (L),
r_w = radius of the well (L),
f_{fp} = porosity of the filter pack.

H_0 typically exceeds H_{0L*}, unless the slug is raised or lowered very slowly, which would invalidate the test.

(b) Open the well.

(c) Perform headspace screening of the well in accordance with the requirements of the work plan and/or HASP.

(d) Don a clean pair of nitrile gloves and measure the static water level using a decontaminated electronic water level meter. If NAPL occurs at the site, verify the absence of NAPL in the well using an oil/water interface probe. Do not conduct a slug test in a well containing NAPL.

(e) If the well was capped with an expansion plug and was not vented, wait for water level stabilization. For the purpose of slug testing, consider stabilization attained when the water level does not vary by more than 0.1 foot over a period of 15 minutes for granular media and a period of 1 hour for fine-grained media.

(f) Record the well designation and location, static water level, and the date and time of the observation in the field logbook.

(g) Determine the depth of deployment of a pressure-sensitive transducer/data logger, which should be a minimum of one foot off the bottom of the well. With the intended depth of deployment from the top of the well casing, measure the corresponding length of transducer cable from the transducer using a tape, and mark the cable where it will be secured at the top of casing. This procedure ensures the initial head of water above the transducer (depth of transducer minus depth of static water level) is known for analysis of the data.

(h) Secure the transducer cable at the wellhead to prevent the transducer from sliding down the well during the slug test.

(i) Confirm the static water level in the well using the electronic water level meter.

(j) Program the data logger/transducer in accordance with the manufacturer's instructions. When using In-Situ® data loggers, the data type should be "water level", the reference should be the top of casing (static water level = depth to water from top of casing), and the time scale (frequency of data collection) may be logarithmic or linear. The data collection frequency should be set to logarithmic for tests in sand and gravel. For tests in fine-grained sediments, a reduced frequency of data collection may be appropriate. The frequency of data collection should be determined with concurrence of the Project Manager/hydrogeologist prior to entering the field. When programming the data logger for each test, the input data must include the well designation, the type of test being performed (*i.e.,* RH – rising head or FH – falling head), and a numeric value corresponding to the sequence of the test for multiple tests on a well.

(k) After programming the data logger/transducer, verify that the water level (head) and/or pressure (2.31 feet/psi) read by the transducer is consistent with the length of the water column above the transducer determined in (g). Most data loggers generate real time water level/head and/or pressure data for viewing on a computer. Consult the manufacturer's instrument manual for the transducer data logger being used.

(l) Raise the transducer by a minimum of six inches measured along the cable with a tape to verify on the computer that the transducer registered the change in head or pressure within the error limits of the transducer. If the change was accurately recorded by the transducer, proceed to step (n) below.

(m) If the change is not accurate within the error limits of the transducer, remove the transducer from service and repeat steps (g) through (l) with a backup transducer.

(n) When performing tests in areas where potential background variations in water level affect the data (*i.e.,* tidal, river stage, or anthropogenic influence), monitor the aquifer with the pressure transducer for an appropriate duration before beginning the test and after complete rebound to determine potential ambient water level trends and adjustments to the data prior to analysis. Pre- and post-test monitoring may also be necessary for tests in a low hydraulic conductivity medium, requiring long rebound periods in which barometric pressure affects water levels.

(o) To perform a rising head test with a slug or a bailer, the slug/bailer is slowly lowered into the well until submerged just below the water surface. Prior to lowering the slug or bailer in the well, the necessary length of the rope attached to the slug/bailer must be measured according to the depth to water and marked to ensure that the top of the slug/bailer will be no more than 6 inches below the static water level. If a solid slug will be used with the intent of conducting a subsequent falling head test, the rope must also be marked so that the bottom of the slug will be no more than 1 foot above the static water level prior to lowering the slug.

(p) Before pulling the slug for the initial rising head test, measure the depth to water to ensure the level has returned to static. Activate the data logger/transducer and in a smooth, rapid motion, withdraw the slug/bailer from the well. Monitor water level rebound using the data logger. When the water level has rebounded (*i.e.,* the difference between the water level and the static water level is less than 5% of the initial displacement), stop the data logger and save the data for the first test.

(q) Before introducing a solid slug for the subsequent falling head test, be sure that the transducer/data logger has been re-programmed with the appropriate information. If a longer slug is used for the falling head test, measure the rope and slug length to mark the rope so that the bottom of the slug will be no more than 1 foot above the static water level prior to lowering the slug. Activate the data logger and lower the slug below the static water level in a smooth, rapid motion to the mark on the rope for complete submergence that was measured for the rising head test. In anticipation of suspending the solid slug, a good practice to avoid disturbing the water during rebound is to affix a 3- to 5-inch long bolt to the rope, depending on casing diameter, at the mark of complete submergence prior to lowering the slug. Monitor water level rebound.

(r) Note that for test initiation, the slugs/bailers should be withdrawn and introduced (solid slug) as quickly as practicable without disturbing the transducer and generating oscillations of the water in the well. Splashing with introduction of the solid slug can be avoided by first slowly lowering the slug a known distance to within a couple of inches of the water, then rapidly lowering it. Good skills in test initiation are acquired through practice, and the necessary rapidity is different for low permeability and high permeability media.

(s) Prior to performing each repeat slug test, measure the water level using the water level meter, record the water level, date, and time of the observation in the field logbook, and re-program the transducer in accordance with (j). Also, record the type of test (RH or FH) and sequence number of the test in the field notebook.

4.2 Pneumatic Slug Tests

Pneumatic slug tests should be considered, if the medium is anticipated to be highly permeable. The pneumatic approach can only be applied to wells with screens that are fully submerged because the procedure requires pressurizing the air column or developing a vacuum in a sealed well. Pressurization is accomplished with compressed air or nitrogen gas, which depresses the water level. A rising head test is initiated, after the air column is rapidly depressurized. Applying a vacuum to the air column raises the water level, and breaking the vacuum initiates a falling head test. Alternatively, a pair of falling- and rising-head tests can be performed in tandem, if both the pressurization (falling-head) and depressurization (rising-head) are conducted very rapidly with respect to the response of the water level.

The pressure required to perform a successful test is not more than 1 to 2 psi. Pneumatic pressurization slug tests should only be performed on wells with screens submerged at least 3.5 feet below the static water level. Otherwise, the pressurization must be carefully performed and monitored to avoid depressing the water level below the top of the well screen. Typical pneumatic displacements range from 10 to 100 cm (0.33 to 3.3 ft), corresponding to 0.14 to 1.4 psi. However, Zurbuchen et al. (2002) present data suggesting the displacement in high permeability media should be limited to 0.87 to 1.5 ft (0.38 to 0.65 psi). Procedures for conducting pneumatic pressurization slug tests are outlined below. Similar steps are applicable to pneumatic vacuum tests. Consult Butler (1998) for additional information and precautions in performing pneumatic slug tests.

a) Perform steps (b) through (n) as described in Section 4.1.

b) Using the static water level (L_s) and well completion log, calculate the length of water column (L_w) from the static water level to the top of the well screen using the following equation:

$$L_w = D_{ws} - L_s$$

Where: D_{ws} = Depth to top of well screen below ground surface (feet);

Note: Static water level must be in feet below ground surface. Measurements made from the top of casing must be adjusted, as appropriate, if the casing is above or below ground surface.

c) Calculate the maximum theoretical pressure (P_{max}) that can be applied during pressurization of the well casing at which the water level is depressed to the top of the well screen:

$$P_{max} = L_w/2.3067 \text{ ft/psi.}$$

The actual air or gas pressure applied to the casing should be less than P_{max}. An applied air pressure of P_{max} less approximately 0.25 to 0.5 psi should maintain the water level between approximately 0.5 and 1 foot above the top of the screen.

d) Verify that the transducer is at least 2 feet below the depth of the intended depressed water level.

e) Attach the pneumatic well-head apparatus to the well casing.

f) Connect the pressurized air or gas supply to the pneumatic well-head apparatus and verify that the bleeder valve on the assembly is closed.

g) Program the data logger and record the hydraulic head or pressure measured with the transducer in a field book or on an appropriate field form. Be sure the data collection frequency is programed to logarithmic.

h) Slowly pressurize the well casing, and check for leaks along the joint between the well-head apparatus and the well casing using a solution of Alconox® and distilled water (or equivalent). As necessary, tighten or re-seat the well-head apparatus, and repeat this step until leaks are eliminated.

i) After leaks are eliminated, pressurize the well to the planned pressure. Record the applied pressure in the field log book or on the appropriate field form.

j) When the transducer has the same reading as the initial reading prior to pressurization, activate the data logger and release the pressure by opening the pressure-release valve on the pneumatic well-head apparatus.

k) After the water level has rebounded, save the test data and re-program the data logger for the next test.

l) After this initial pressurization procedure for a rising head test, a pair of falling- and rising-head tests could be performed in tandem, if the water level response is monitored during pressurization as well as after the pressure is released. The pressurization (falling-head) and depressurization (rising-head) must be conducted very rapidly with respect to the response of the water level. The falling-head test terminates when the pressure in the well reaches equilibrium (the transducer has the same reading as the initial reading prior to pressurization).

m) Multiple tests should be performed at different displacements in accordance with recommendations in Section 3.1.

5.0 DECONTAMINATION

Reusable equipment, including water level meters, measuring tapes, transducers, and slugs will be thoroughly decontaminated using a solution of Alconox™ and/or Liquinox™ followed by a rinse with distilled water prior to and following uses at different wells to avoid cross-contamination. Equipment that cannot be readily decontaminated (*e.g.,* slugs that are heavily contaminated) will be discarded after each use and managed as investigation-derived waste (IDW).

6.0 INVESTIGATION-DERIVED WASTE DISPOSAL

IDW generated during slug tests includes expendable equipment (*i.e.,* unusable slugs, rope, and PPE) and decontamination residuals and supplies. These materials will be managed as IDW in accordance with the project FSP.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Upon completing each test, the data should be reviewed on a field laptop computer. For wells exhibiting a moderate to high rate of rebound, a plot of the water level rebound versus time should exhibit an asymptotic trend. Wells exhibiting a low rate of rebound will typically exhibit a linear response, unless monitoring is continued for an extended duration. Deviations from this response pattern may indicate problems, and the test may be repeated when the water level has rebounded to static conditions.

It is good practice to perform multiple (*e.g.,* 2 to 3 rising and 2 falling head) tests in each well with two different water level displacements (*i.e.,* using two different slug sizes) to assess the validity of the hydraulic conductivity estimates (*i.e.,* not affected by poor well development).

8.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

At the end of each day, or more frequently as necessary, data will be downloaded to a laptop computer and emailed to the data manager for retention in the project file pending analysis. The data should also be saved to a flash drive to prevent inadvertent data loss.

The field logbook should be used to record the following information, at a minimum:

- Weather conditions at the time of testing;
- The make, model, pressure rating, accuracy rating, and serial number of the pressure transducer used to record water level data;
- Well designation and location;
- The static depth to water and total depth of the tested well;
- The depth of the transducer in the tested well below its measurement point;
- Reference point from which all measurements are made;
- The type of test (RH or FH);
- The expected displacement, or the pneumatic pressure and displacement; and
- Time that the test is started and stopped.

Any deviations from the record management procedures specified in the FSP or Quality Assurance Project Plan, if applicable, must be approved by the QA Officer and Project Manager and documented in the field logbook.

9.0 REFERENCES

Butler, J.J., 1998. *The Design, Performance, and Analysis of Slug Tests*. Lewis Publishers, Boca Raton, Florida.

Cunningham, W.L., 2010. *Conducting an Instantaneous Change in Head (Slug) Test with a Mechanical Slug and Submersible Pressure Transducer*, United States Geological Survey.

Zurbuchen, B.R., V.A. Zlotnik, and J.J. Butler, 2002. *Dynamic interpretation of slug tests in highly permeable aquifers*. Water Resources Research, v. 38, no. 3, p. 7-1 to 7-18.

10.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	FEBRUARY 2019	Not applicable.

Soil Vapor Intrusion Procedures

Title: **Soil Vapor Point Installation and Active Vapor Sampling**	Procedure Number: **ECR 015**
	Revision Number: **1**
	Effective Date: **August 2017**

Authorization Signatures

Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Stacy Metz	8/2/17	Elizabeth Denly	8/2/17

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1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in active soil vapor sampling activities. This SOP details equipment and sampling procedures for low-flow sampling from temporary or permanent soil vapor points as well as the procedures for installation of these soil vapor points. The focus of this SOP is on evacuated canister sampling; other sampling containers such as evacuated bottles or Tedlar® sampling bags may be appropriate but are not covered in this SOP. Various regulatory agencies and project-specific work plans may have different specific requirements (e.g., equipment/instrument, flow rate) which may supersede this SOP, depending on the program.

The objective of soil vapor sampling is to obtain a representative sample of vapor from the vadose zone immediately below the floor of a building or other area of concern. Areas of concern may be within, above, or adjacent to a soil or groundwater contaminant source area.

1.2 Summary of Method

This method has been developed to describe how to collect representative samples of soil vapor from the vadose zone. Temporary or permanent points can be installed depending on project objectives. Installation of several types of permanent and temporary points are described herein. Sample collection methods include verification that a representative soil vapor sample has been collected and that the sample was not compromised by leakage of sampling components or the sampling point itself. Field verification of sample integrity may include a shut-in leak test, quantitative tracer testing, and/or semi-quantitative tracer testing, depending on project objectives and regulatory requirements. Leak detection is an integral part of soil vapor sampling and is explained in detail in Attachment D. Photographs referenced within this SOP are included in Attachment A. Soil vapor point diagrams referenced within this SOP are included in Attachment B.

1.3 Equipment

The following equipment list is meant to be a guide of the typical equipment that can be used to install a soil vapor point and collect a soil vapor sample, unless project needs dictate a different set of equipment. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Applicable Safety Data Sheets (SDSs)
- Non-powdered, disposable gloves
- Field logbook and/or appropriate field forms
- Digital camera
- Calculator

Installation of Permanent Points via Flush-mount Well Cover Method (Section 2.1.2):

- Soil vapor probe materials (stainless-steel or brass):
  - $^{1}/_{4}$-inch diameter ball valve;
  - $^{1}/_{4}$-inch male thread by $^{1}/_{8}$-inch diameter hose barb fitting;
  - $^{1}/_{4}$-inch diameter nipple (length dependent upon slab thickness)
- Alconox® or equivalent
- Distilled water
- Teflon® tape
- Wrenches
- Appropriate field screening device(s), e.g., photoionization detector (PID), flame ionization detector (FID), and/or landfill gas meter (optional)
- If concrete coring is required*:
  - Concrete coring machine with diameter approximately 2-inches larger than well cover
  - Concrete core barrel
  - Extension cord(s)
  - Heavy-duty vacuum (e.g., Shop-Vac®)
  - Generator, if needed
- Source of clean water and buckets or hose
- Paper towels
- Aluminum flush-mount well cover, typically 4-inch diameter
- Reciprocating saw with metal cutting blades
- Hydraulic cement or equivalent
- Grout/Portland cement
- Trowel and other tools to mix and place cement

*Common to have driller or qualified subcontractor perform the coring; see Project Manager for instructions.

Installation of Permanent Points via Stainless-steel Probe Method (Section 2.1.3):

- Soil vapor probe materials:
  - $^{1}/_{4}$-inch outer diameter (OD), gas chromatography grade 316 stainless-steel tubing
  - $^{1}/_{4}$-inch stainless-steel coupling with a female National Pipe Thread (NPT) fitting (top) with ¼-inch OD tubing compression fitting (bottom)
  - $^{1}/_{4}$-inch male NPT plug
  - Stainless-steel washer, optional ($^{3}/_{8}$-inch inner diameter [ID], OD less than 1-inch and greater than $^{1}/_{2}$-inch)
- Alconox® or equivalent
- Distilled water
- $^{7}/_{16}$-inch socket
- Wrenches
- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Rotary hammer drill equipped with 1-inch drill bit
- Rotary hammer drill equipped with $^{3}/_{8}$-inch or $^{1}/_{2}$-inch drill bit
- Extension cord(s)
- Paper towels

- Heavy-duty vacuum (e.g., Shop-Vac®), optional
- Stainless-steel tubing cutter
- Granular bentonite or bentonite/cement
- Flathead screwdriver
- Hydraulic cement or equivalent
- 1-inch diameter sink hole cover

Installation of Temporary Sub-slab Soil Vapor Points (Section 2.1.4):

- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Rotary hammer drill equipped with 1-inch drill bit
- Rotary hammer drill equipped with $^{3}/_{8}$-inch or $^{1}/_{2}$-inch drill bit
- Extension cord(s)
- Generator, if needed
- Paper towels
- Distilled water
- Teflon® or Teflon®-lined polyethylene tubing
- Scissors or tubing cutter
- Granular bentonite
- Container for preparing bentonite
- Materials to close sample port during equilibration, one option outlined below:
    - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
    - $^{1}/_{4}$-inch barbed fitting (such as Cole Parmer EW-45503-19)
    - $^{1}/_{8}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
    - $^{1}/_{4}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
- Materials to create appropriate surface seal/patch on abandoned borehole
    - Pre-mixed, non-shrinking grout (quick-dry)
    - Container for preparing grout
    - Concrete tools (trowel and $^{1}/_{4}$-inch diameter rod)

Installation of Permanent Deep Soil Vapor Points (Section 2.1.5):

- Soil vapor probe materials:
    - Stainless-steel mesh vapor point with ¼-inch barb fitting or with a ¼-inch compression fitting
    - $^{1}/_{4}$-inch OD inert tubing (such as Teflon® or Teflon®-lined polyethylene)
- Alconox® or equivalent
- Distilled water
- Teflon® tape, if compression fitting is used
- Wrenches, if compression fitting is used
- Scissors or tubing cutter
- Zip ties, if barbed fitting is used
- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- If concrete coring is required*:
    - Concrete coring machine
    - Concrete core barrel with diameter approximately 2-inches greater than well cover
    - Extension cord(s)

- Heavy-duty vacuum (e.g., Shop-Vac®)
- Generator, if needed

- Hand auger
- Direct-push drilling equipment equipped with 3-inch rods, recommended**
- Measuring tape
- Appropriate materials to decontaminate drilling equipment between locations
- Source of water for decontaminating
- Paper towels
- Filter pack of glass beads (60-100 mesh) or fine sand (20-40 mesh), or other appropriately sized inert material based on stainless-steel probe manufacturer recommendations
- Medium sand (optional)
- Granular bentonite
- Grout/Portland cement, or equivalent
- Shovel
- Aluminum flush-mount well cover, typically 4- to 8-inch diameter
- Redi-Mix concrete
- Sand or gravel for drainage layer
- Materials to close sample port, one option outlined below:
    - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
    - $^{1}/_{4}$-inch barbed fitting (such as Cole Parmer EW-45503-19)
    - $^{1}/_{8}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
    - $^{1}/_{4}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)

*Common to have driller or qualified subcontractor perform the coring; see Project Manager for instructions.

**In certain geologic conditions (e.g., hole stays open to target depth), deep soil vapor points may be installed with a hand auger. However it is typically recommended that a qualified driller install the borehole with direct push drilling equipment. Direct push methods minimize the sub-surface disturbance, reducing the likelihood of leaks and short-circuiting during sample collection.

Installation of Temporary Deep Soil Vapor Points (Section 2.1.6):

- Appropriate field screening device(s), e.g., PID, FID, and/or landfill gas meter (optional)
- Hand auger, if required
- Direct-push drilling equipment, recommended*
- Appropriate materials to decontaminate drilling equipment between locations
- Source of water for decontaminating
- Teflon® or Teflon®-lined polyethylene tubing
- Scissors or tubing cutter
- Sand
- Measuring tape
- Granular bentonite
- Distilled water
- Materials to close sample port during equilibration, one option outlined below:
    - Polycarbonate stopcock (such as Cole Parmer EW-30600-01)
    - $^{1}/_{4}$-inch barbed fitting (such as Cole Parmer EW-45503-19)

    - $^{1}/_{8}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
    - $^{1}/_{4}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
- Materials to create appropriate surface seal/patch on abandoned borehole
    - Pre-mixed, non-shrinking grout (quick-dry)
    - Container for preparing grout
    - Concrete tools (trowel and $^{1}/_{4}$-inch diameter rod)

*In certain geologic conditions (e.g., hole stays open to target depth), deep soil vapor points may be installed with a hand auger. However, it is typically recommended that a qualified driller install the borehole with direct push drilling equipment. Direct push methods minimize the sub-surface disturbance, reducing the likelihood of leaks and short-circuiting during sample collection.

Sample Collection:

- Pre-cleaned, evacuated, passivated stainless-steel canister (hereafter - sampling canister), at least one extra for every 20 samples recommended in case of leakage
- Flow controller(s) with flow rate pre-set by laboratory to meet project objectives, typically between 100 and 200 milliliters per minute (mL/min)
- Digital vacuum gauge, optional
- $^{1}/_{4}$-inch diameter Teflon®, Teflon®-lined, Nylaflow® and/or other inert tubing (optional)
- Applicable components to form sample collection train; components will vary depending on sample point construction and project requirements, but may include:
    - Stopcock (such as Cole Parmer EW-30600-01, or similar)
    - In-line moisture filter (e.g., Millipore #SLGVS25US, or equivalent)
    - ¼-inch barbed fittings (such as Cole Parmer EW-45503-19)
    - Flexible tubing (do NOT use silicone)
        - $^{1}/_{8}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 16)
        - $^{1}/_{4}$-inch ID Tygon E-Lab Tubing (E-3603, L/S 17)
    - $^{1}/_{4}$-inch OD stainless-steel tee
    - $^{1}/_{4}$-inch OD stainless-steel port connectors
    - $^{1}/_{4}$-inch stainless-steel nuts and ferrules
    - $^{1}/_{4}$-inch OD stainless-steel ball valve
    - $^{1}/_{4}$-inch O-rings
    - $^{1}/_{4}$-inch OD, gas chromatography grade 316 stainless-steel male/male coupling
- Teflon® tape
- Zip ties
- Scissors or tubing cutter
- Appropriate tools to open sample collection points (project-specific)
    - Sockets ($^{7}/_{16}$-inch, $^{1}/_{2}$-inch, and/or $^{3}/_{8}$-inch) and driver;
    - Wrenches;
    - Allen wrench, and/or
    - Flat-head screwdriver
- Granular bentonite
- Distilled water
- 50 mL graduated syringe or pump to purge sample port (inert gas detector for tracer gas testing may also serve this purpose)

- Flexible tubing (material does not matter) to form connection between syringe or pump and sample point
- Air flow rate meter (e.g., DryCal® DC-Lite), optional (see Section 2.2.3)
- Watch or timer (capable of monitoring time to the nearest second)
- PID, FID, landfill gas meter and/or other project-specific field screening devices (optional)
- Materials required for completing project-specific leak-testing; equipment lists for various leak-test options are provided in Attachment D

1.4 Definitions

Active Soil Vapor Sampling — A volume of soil vapor or soil gas is pumped out of the vadose zone into a sample collection device for analysis.

Batch Certification — A laboratory will clean several sampling canisters at once. One canister from that group of canisters, i.e., the batch, is used to certify that all of the canisters in that batch are clean.

Building Stack Effects — The natural phenomenon of how air moves in and out of a building primarily due to pressure and temperature differences. Buildings are not totally sealed – they leak. Since air density decreases with increasing warmth, in cool or cold weather, warm interior air tends to leak from the upper portion of the building and cooler air tends to infiltrate the bottom of the building. In air conditioned buildings, this phenomenon is reversed causing warmer exterior air to infiltrate the upper portion of the building and cooler interior air to leak from the bottom portion of the building. These building stack effects can cause increased soil vapor flux around the building perimeter. This increased flux tends to be greater for large buildings because the total building area is relatively high in comparison to the building perimeter.

Individual Certification — A laboratory will clean several sampling canisters at once. Each canister from the batch is certified clean.

Passive Soil Gas Sampling — A sampler containing a sorbent material with an affinity for the target analytes is placed in the ground for a period of time, so that contaminant vapors can be adsorbed over time using the ambient flow of soil gas.

Purge Volume — The total volume, typically measured in milliliters (mL), of air/gas/vapor contained within the sample collection system and sampling point (e.g., tubing, void space within the boring, and/or void space below the slab).

Selected Ion Monitoring (SIM)	Analysis using gas chromatography/mass spectrometry (typically EPA TO-15), whereby only those masses of the known contaminants of interest in the known elution time period are scanned instead of scanning a wide range of masses (35-500 atomic mass units [amu]) every second. SIM analysis allows for greater specificity and much greater sensitivity than scanning in the full-scan mode, since the mass spectrometer is set to dwell for longer period times on a restricted number of masses. SIM analysis is most common for indoor air sample analysis, and is typically not required for soil vapor sample analysis.
Vadose Zone	The zone of soil above the water table and below the ground surface in which the pores between soil grains are at least partially filled with vapor.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous materials and TRC personnel must appropriately handle and store them at all times. SDSs must accompany reagents or compressed gases.

The rotary hammer drill bits can become extremely hot during drilling. The proper gloves should be worn during drilling to prevent serious burns.

Drilling equipment including the concrete coring machine, the rotary hammer drill, and the Geoprobe® may generate dust and noise; therefore, a dust mask and/or hearing protection should be worn during use, as conditions warrant.

The appropriate cut-/puncture-resistant gloves should be used for this task. Refer to the Glove Section Guidelines in TRC's Hand Protection Policy.

1.6 Cautions and Potential Problems

(a) Compression fittings, where applicable, as opposed to tube-in-tube connections are typically recommended for air sampling. However, over tightening compression fittings may cause damage/deformation, resulting in leakage during subsequent use. Any leaks of ambient air through fittings between pieces of the sampling train will dilute the sample. The integrity of connections within the sampling train should be verified with a shut-in leak test, or equivalent.

(b) Leaks within the sample collection apparatus may result in leakage of ambient air, and a low sample bias. Leak testing must be performed to verify that a representative sample is collected. Note that certain laboratories, particularly those which specialize in ambient air, indoor air, or stack-testing rather than soil vapor testing, may not maintain their equipment to the standard required to pass a shut-in leak test. Typical leakage rates during shut-in leak tests should be less than 5-percent. If higher leakage rates are observed for the canister-flow controller connection, an alternative laboratory should be considered. If needed, experienced personnel on the TRC Vapor Intrusion CORE Team can provide a recommendation for a laboratory which maintains sampling canisters and flow controllers to the necessary standard for soil vapor sampling.

(c) Water vapor in the sample may compromise the laboratory instrumentation and prevent sample analysis. Measures should be taken to prevent moisture from entering the sampling canister. Soil vapor points should not be in contact with the water table. In many environments, soil vapors may be high in moisture, and condensate may form with temperature fluctuations (particularly at exterior locations or at inactive sites where heating/cooling systems are not operational). Sample collection lines should be monitored for visible moisture. Typically, an in-line moisture filter should be used during sample collection to prevent unacceptable levels of moisture from compromising the sample. If water is observed, the possible presence of water in the sample should be noted on the chain-of-custody. If the laboratory knows that water may be present, measures can be taken to prevent the water from entering the instrumentation.

(d) The inert gas detector may yield a false positive response in high moisture conditions. Under these conditions, it is recommended that an alternative semi-quantitative tracer, such as 1,1-difluoroethane (commercially available as electronic dusting spray), be used in place of inert gas tracer testing.

(e) Although sampling equipment (e.g., flow controllers and sampling canisters) is typically not damaged by extreme temperatures, the functionality of sampling equipment may be temporarily affected by extreme temperatures. Protect the flow controller and sampling canister from extreme temperatures (<20°F) immediately prior to and during sample collection.

(f) The sampler should be cognizant of the purge volume of the sample tubing and should remove at least one purge volume prior to inert gas testing and three purge volumes prior to sample collection. Purging a point is similar to purging a groundwater monitoring well in that under purging can create a low bias. Do not purge more than five volumes of the tubing and/or sampling point. Significant over purging can cause low bias and sample representativeness issues, as soil vapor that has accumulated adjacent to the sampling point could be evacuated and vapor from beyond the target sampling location would then migrate to fill the low-pressure zone. If a PID, FID, landfill gas meter or other field screening device is used prior to sample collection, caution should be used regarding the number of purge volumes being removed.

(g) Many common construction materials, particularly plastics have the potential to absorb volatile organic compounds (VOCs). Sampling points should be constructed using stainless-steel, brass, Teflon®, Teflon®-lined, Nylaflow® and/or other materials that have been demonstrated to be inert in soil vapor/air sampling applications.

(h) Teflon®, Teflon®-lined, Nylaflow®, and/or other tubing that has been shown to be inert should be used to the extent possible in the sample collection train. Flexible tubing has the potential to absorb small amounts of VOCs. Therefore the use of flexible tubing should be minimized to the extent reasonable. However short sections of flexible tubing are often required to make air-tight connections within the sample collection apparatus. Flexible silicone tubing should not be used for these connections. Depending on the manufacturing process, certain batches of silicone tubing may release siloxane vapors. These vapors may cause matrix interference and compromise sample reporting limits. Short sections of Tygon® tubing are recommended as opposed to silicon tubing where flexible tubing is necessary. Due to the potential for VOC absorption/desorption, flexible tubing within the sample collection train should be replaced prior to each sampling event.

(i) Many common materials can contain VOCs. Eliminate to the extent possible the use of VOC-containing materials (e.g., perfumes, glues, modeling clay, etc.) during sample point installation and sample collection. If possible, fuel your field vehicle prior to loading field equipment. Make sure hands are washed thoroughly after fueling a vehicle, and prior to handling sampling equipment. Note even sealants, glues, clay, etc. which are labeled "VOC-free" may contain VOCs at parts per billion levels, i.e., the anticipated sensitivity of the sample analysis. These materials also may contain other chemicals which affect analytical instrumentation, even if they are not target chemical (e.g., siloxanes). "Party" helium contains measurable concentrations of several VOCs and should not be used in place of laboratory-grade helium for inert gas tracer testing.

(j) If collecting indoor air at the same locations and at the same time as sub-slab vapor samples, purging should be performed into a Tedlar® bag instead of into ambient air to avoid cross-contamination.

(k) Low permeability soils can cause short-circuiting of soil vapor samples such that ambient air is pulled down through preferential pathways in the soil and collected in place of soil vapor.

(l) In low permeability soils exhibiting high moisture content, active soil vapor sampling methods have the potential to underestimate concentrations of constituents of interest, particularly if impacts are confined to a small area.

(m) If the sampling canister vacuum fails to drop, this may be the result of low permeability soils, cold weather, or other equipment-related issues, which may require troubleshooting. If the problem cannot be resolved, contact the Project Manager to determine how to proceed, as the sampling canister is not filling properly and inadequate sample volume will lead to elevated reporting limits and potential issues with the representativeness of the sample.

(n) Note that the final target vacuum may vary depending on the project and regulatory requirements. Verify appropriate requirements prior to collecting samples. Some projects require that there be some residual vacuum remaining in the canister (typically 2-6 inches mercury [in. Hg]). A field vacuum reading similar to the laboratory receipt vacuum provides a check of the integrity of the canister and demonstrates that no leaks occurred during shipment to the laboratory. Other guidance recommends letting the canister fill completely (e.g., final vacuum of 0 in. Hg); filling the canister to zero eliminates the pressure gradient between the canister and ambient air during sample shipment.

(o) Where constituents of interest exhibit moderate Henry's Law Coefficients (on the order of 10^{-5} atmospheres-meter^3/mole), a short sample period may result in false negatives or low biases potentially associated with the low exchange of air during active sampling. Examples of potential compounds of interest with moderate Henry's Law Coefficients include but are not limited to: Acetonitrile, 4,4'-DDT, dieldrin, and 1,4-dioxane.

(p) Caution should be used when collecting soil vapor at exterior soil vapor sampling locations.

- Depth of Exterior Soil Vapor Points: Typically sampling points that are less than 5 feet below ground surface (ft. bgs) are not recommended. Risk, estimated using shallow exterior soil vapor points, is likely to be underestimated due to leakage of ambient air, particularly adjacent to a building, where the air exchange rate in the soil vapor may be influenced by building stack effects due to heating/cooling systems.
- Moisture: Significant recharge events (e.g., rainfall or snow melt) can temporarily "wash" the vadose zone. Soil vapor sampling at exterior locations should be delayed for at least 48-hours after a significant recharge event. Significant recharge events by definition vary from state to state. If available, check applicable guidance to confirm definition of significant recharge.

(q) In certain situations, it may be more appropriate and cost effective to perform a screening level assessment using an alternative method to reduce or eliminate the need for active soil vapor sampling. For instance:

- Under some regulatory programs, it may be possible to use field screening (e.g., PID, FID) to eliminate the collection of canister samples.
- Passive soil gas sampling modules may be effective in overcoming many limitations to active soil vapor sampling such as low permeability soils, high moisture soils, constituents of interest with moderate Henry's Law Coefficients, and/or the high costs associated with large investigation areas. In certain situations, passive soil gas sampling may be used to eliminate or greatly reduce the need for more costly active soil vapor sampling.

(r) If using a generator during sample point installation, operate the unit away from the sampling area and be sure that the exhaust of the generator is not directed towards the sample or any of the field team members.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Always review the project-specific work plan and/or scope of work for any site-specific sampling procedures. The following sections detail the methods available for installing soil vapor sampling points and collecting active soil vapor samples.

2.1 Installation of Soil Vapor Sampling Points

This section describes several ways to install soil vapor sampling points. The methods described herein are not exhaustive. Other methods for sample point installation may be appropriate depending on regulatory requirements and project objectives. In general soil vapor sampling points must be constructed of inert materials which neither absorb nor desorb VOCs, e.g., stainless-steel, brass, Teflon®, Teflon®-lined, and/or Nylaflow® materials. Additionally soil vapor sampling points must be constructed in a manner that ensures the soil vapor sample is collected from the target sample location and sealed to prevent ambient air leakage.

2.1.1 Pre-installation Activities

Pre-installation activities may include, but are not limited to, the following:

- Premark sampling locations and contact the appropriate entity to locate underground utilities in the area. Confirm sampling locations with the site owner.
- Where soil vapor points are to be installed through concrete or similar, screen cracks, gaps and other annular spaces in the surrounding area with a PID that is approved by the local regulators or is otherwise appropriate for the application. For example, the RAE System ppbRAE model, which is sensitive to 1 part per billion volume (ppbv) is approved in some states and is recommended where allowed.
- Check the depth to water in nearby wells to determine if the slab may be in contact with the water table (especially if in the basement), or for deep points, to help ensure that the sampling point is installed above the water table and capillary fringe.

2.1.2 Installation of a Permanent Sub-slab Vapor Point – Flush-Mount Well Cover Method

This subsection describes the procedure for installing a permanent sub-slab vapor point using the Flush-mount Well Cover Method. Using the Flush-mount Well Cover Method, the sampling point is protected by a flush-mount well cover or small manhole cover. This installation method is recommended in commercial and industrial settings, particularly in areas of high and/or heavy traffic. See Figure B-1 in Attachment B for a cross-sectional diagram of a point installed using the Flush-mount Well Cover Method.

If the slab is thin (e.g., one-inch thick), caution should be used because the probe and flush-mount well cover skirt will need to be cut very short and should not extend more than one or two inches deeper than the base of the slab.

Construction: Permanent Flush-Mount Well Cover Sampling Point

(a) Components:

- $^1/_4$-inch diameter ball valve;
- $^1/_4$-inch male thread by $^1/_8$-inch diameter hose barb fitting; and,
- $^1/_4$-inch diameter nipple (length dependent upon slab thickness).

(b) Decontaminate any cutting oils from the components using Alconox® or equivalent, and rinse with distilled water.

(c) Attach Teflon® tape to all threads that will be attached to other components.

(d) Attach the hose barb fitting to the ball valve, and use a wrench to tighten securely. Ensure that the ball valve lever is up, toward the barb fitting, when open so that the valve can be opened and closed after installation.

(e) Attach the nipple to the base of the ball valve, and use a wrench to tighten securely.

Installation: Permanent Flush-Mount Well Cover Sampling Point

(a) Select drilling location. Advance core barrel through the concrete slab and remove the core. Recover the concrete coring water with a heavy-duty vacuum. The concrete core should be large enough to set, grout and seal the flush-mount well cover (typically about 2-inches larger in diameter than the flush-mount well cover).

(b) Place the flush-mount well cover in the center of the core. If needed, cut the skirt so the flush-mount well cover is flush with the floor.

(c) Remove the flush-mount well cover lid, and install the prepared sampling point in the center of the flush-mount well cover by placing it in the flush-mount well cover, so the base is in contact with the sub-base materials. Cut the base of the sampling point, so the top of the point sits just below the lid of the flush-mount well cover.

(d) Install hydraulic cement from the base of the flush-mount well cover up to the base of the ball valve on the sampling point. Then install hydraulic cement or grout/Portland cement between the flush-mount well cover and the concrete slab to match the flush-mount well cover and existing grade.

(e) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(f) Ensure the ball valve is in the closed position before closing the lid. Clean work area. Refer to Photograph 1 for a picture of a newly installed point prior to the placement of the lid.

(g) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.3 Installation of a Permanent Sub-slab Vapor Point – Stainless-steel Probe Method

This subsection describes the procedure for installing a permanent sub-slab vapor point using a stainless-steel probe, often referred to as the Swagelok® Method. This method was described in a United States Environmental Protection Agency report titled "Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples" (USEPA, 2006). Probes should be constructed prior to ground-intrusive activities.

Sub-slab vapor point installation with a stainless-steel probe does not require concrete coring. Consequently, the Stainless-steel Probe Method is typically less expensive than the Flush-mount Well Cover Method, and is generally recommended in residential settings. Using the Stainless-steel Probe Method, the sample point is largely unprotected. Dirt and debris may fill the sampling point. The threading on the stainless-steel coupling must be clean prior to sampling to ensure a good seal. See Figure B-2 in Attachment B for a cross-sectional diagram of a point installed using the Stainless-steel Probe Method.

Construction: Permanent Stainless-steel Probe Sampling Point

(a) Assemble soil vapor probes using a project-specific length of $^{1}/_{4}$-inch OD stainless-steel tubing connected to the $^{1}/_{4}$-inch compression fitting on a stainless-steel coupling. Install a $^{1}/_{4}$-inch male NPT plug in the female NPT fitting end of the stainless-steel coupling and tighten 270 degrees; this plug will be mounted flush with the ground surface and removed to access the soil vapor probe. See Photograph 2 for a picture of the components.

(b) Decontaminate any cutting oils from the components using Alconox® or equivalent, and rinse with distilled water.

Installation: Permanent Stainless-steel Probe Sampling Point

(a) Using a rotary hammer drill, advance a 1-inch diameter drill hole into the concrete floor to a depth approximately 2 inches below the surface. Photograph 3 is a picture of a typical rotary hammer drill.

(b) Remove the accumulated powdered concrete from the boring using a wet paper towel or vacuum.

(c) Switch to the $^{3}/_{8}$-inch diameter drill bit ($^{3}/_{8}$-inch diameter needed for the $^{1}/_{4}$-inch stainless-steel tubing) and advance the boring through the remainder of the concrete slab and into the sub-slab aggregate. **NOTE:** A different rotary hammer drill than the one used in step (a) will most likely be needed for the $^{3}/_{8}$-inch diameter drill bit. Do not advance the boring greater than 2 inches past the base of the concrete slab. Clean the inside of the boring with a wet towel or similar to remove powdered concrete. In order to eliminate the need for a second, smaller rotary hammer drill, a $^{1}/_{2}$-inch diameter bit can be used provided the probe does not slide down the $^{1}/_{2}$-inch diameter borehole. A decontaminated, stainless-steel washer can be placed at the base of the one-inch diameter borehole to ensure that the probe does not slip down.

(d) Measure the depth of the concrete slab using the drill bits.

(e) Compare the depth of the concrete slab to the length of the assembled probe. The plug should be either flush or very slightly below the surface grade of the concrete slab. Cut the base of the sampling point with a stainless-steel tubing cutter if the probe assembly is longer than the concrete slab is thick. The point should "float" in the concrete slab.

(f) Re-drill using the $^{3}/_{8}$-inch (or $^{1}/_{2}$-inch) diameter drill bit to push any extra concrete powder down the borehole, so it does not interfere when inserting the probe.

(g) Place the probe assembly into the borehole.

(h) Carefully add granular bentonite or a bentonite/cement mix around the probe. Hydrate with distilled water. Use a flat head screwdriver, to mix the bentonite and fill the annulus from the top of the tubing (i.e., the base of the 1-inch diameter borehole) to approximately 1-inch below grade. See Figure B-2 in Attachment B. Use a paper towel to remove excess bentonite.

(i) Photograph 4 is a picture of a point prior to the installation of the hydraulic cement. Install a hydraulic cement cap above the bentonite and below the threads of the plug. Non-shrinking or expanding cements that do not contain VOCs can be substituted.

(j) A 1-inch diameter pronged sink hole cover may be installed over the sampling point for aesthetic purposes, and to reduce the potential for dirt egress into the sampling point. The sink hole cover can be removed with a flat-head screwdriver prior to sampling.

(k) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(l) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.4 Installation of a Temporary Sub-Slab Soil Vapor Point

This subsection describes the procedure for installing a temporary sub-slab vapor point. See Figure B-4 in Attachment B for a cross-sectional diagram of an installed temporary sub-slab soil vapor sampling point.

Installation Temporary Sub-Slab Soil Vapor Sampling Point

(a) Use the rotary hammer drill to advance the 1-inch diameter drill bit approximately 1-inch into the concrete. See Photograph 3 for a picture of a typical rotary hammer drill.

(b) Remove the accumulated powdered concrete from the boring using a wet paper towel.

(c) Switch to the $^3/_8$- or $^1/_2$-inch diameter drill bit and advance the boring through the remainder of the concrete slab and into the sub-slab aggregate. **NOTE:** A different rotary hammer drill than the one used in step (a) will most likely be needed for the $^3/_8$-inch diameter drill bit. Do not advance the boring more than 2 inches past the base of the concrete slab. Clean the borehole with a wet paper towel; do not use a vacuum which could purge air from the sub-slab and affect the representativeness of the sample.

(d) Install Teflon® or Teflon®-lined polyethylene tubing into the base of the boring. Ensure the tubing is long enough to pass through an inert gas containment structure (if required for leak-testing) and connect to a sampling canister.

(e) Using the dedicated bentonite mixing container, hydrate a sufficient amount of granulated bentonite with distilled water to fill the boring diameter and seal around sampling tube. The bentonite seal will require monitoring as it will begin to dry. Rehydrate as necessary.

(f) Install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, sample closure is assembled as described below and illustrated in Photograph 5:
1. Install $^1/_8$-inch ID Tygon tubing over slip end of stopcock
2. Cut tubing flush with the end of the stopcock.
3. Form a tube-in-tube connection with ¼-inch ID Tygon tubing over $^1/_8$-inch ID Tygon tubing.
4. Cut ¼-inch ID Tygon tubing to extend approximately 1-inch beyond the end of the stopcock.
5. Form another tube-in-tube connection by placing the open end of the ¼-inch ID Tygon tubing over the ¼-inch Teflon® tubing of the sample point.

(g) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(h) After the vapor point has been installed, adequate time should be allowed for the subsurface to return to equilibrium conditions. The equilibration time will be dependent on the degree of soil disturbance during installation and regulatory requirements. The Project Manager should be consulted to determine the optimal/required equilibration time. Photograph 6 is a photograph of a temporary sub-slab vapor point during sample collection.

Decommission: Temporary Sub-Slab Soil Vapor Sampling Point

After sample collection is complete, decommission the temporary sampling point as described below.

(a) Remove the tubing from the boring.

(b) Either excavate the bentonite seal or push to the base of the boring.

(c) Abandon vapor point boring with non-shrinking grout or cement.

(d) Clean up the work area.

2.1.5 Installation of a Permanent Deep Soil Vapor Point

This subsection describes the procedure for installing a permanent deep soil vapor point. Unlike sub-slab sampling points, deep sampling points may be located at interior or exterior locations. The surficial completion of the point is similar to the sub-slab Flush-mount Well Cover Method; however the sampling point itself is a mesh, stainless-steel screen point, as shown in Photograph 7. See Figure B-3 in Attachment B for a cross-sectional diagram of a permanent deep soil vapor point. Multiple vapor points may be installed in the same borehole.

Construction: Deep Soil Vapor Point

(a) Decontaminate any cutting oils from the stainless-steel components of the vapor point using Alconox® or equivalent, and rinse with distilled water.

(b) Assemble the soil vapor probe using a stainless-steel mesh vapor point and $^{1}/_{4}$-inch OD Teflon® or Teflon®-lined tubing. The stainless-steel mesh vapor point may be constructed with either a compression fitting or a barbed fitting.
   1. Cut the tubing to a length approximately 24-inches longer than the target installation depth.
   2. Connect the tubing to the stainless-steel mesh vapor point. Use Teflon® tape and/or zip ties as appropriate to ensure a good seal.
      i. If a compression fitting is used, slide the nut and ferrule (from the vapor point) over the sample tubing. Insert tubing into the coupling on the vapor point. Slide ferrule down until seated firmly. Connect the nut to the coupling and tighten, but do not over tighten (approximately 270 degrees).
      ii. If a barbed fitting is used, make the tube-in-tube connection and verify tightness.

Installation: Deep Soil Vapor Point

(a) Select drilling location. Verify the utilities have been marked and ensure location is located safely away from subsurface utilities. Hand dig if appropriate. If sampling location has a concrete surface proceed to Step (b) below. If concrete is not present, skip Step (b) and proceed to Step (c) below.

(b) If concrete is present at sampling location, use concrete coring equipment to core through the concrete surface and remove the core. The concrete core should be large enough to set, grout and seal the flush-mount well cover (typically about 2-inches larger in diameter than the flush-mount well cover).

(c) Use direct push drilling technologies (e.g., Geoprobe®) to advance a borehole having a minimum diameter of 3-inches to approximately six inches below the target sampling depth.

(d) Install the deep soil vapor point, assembled as described in the Construction section above, to the total depth through the Geoprobe® rods.

(e) Carefully create a filter pack using appropriately sized glass beads or clean sand to approximately 6-inches above the top of the screened interval, backfilling the deep soil vapor point through the Geoprobe® rods if possible.

(f) Slowly remove rods, being careful not to pull or otherwise disturb the sampling point. Use a clean measuring tape to verify that the height of the filter pack remains at least 6-inches above the top of the screened interval. Add additional filter pack material as appropriate.

(g) A thin (1- to 4-inch) layer of clean medium sand may be placed above the filter pack to help prevent the egress of hydrated granular bentonite into the filter pack.

(h) Seal the well annulus using granular bentonite from the top of the filter pack, or medium sand layer, to a depth of approximately 2 ft. bgs. Place granular bentonite above the filter pack material in 3 to 6-inch lifts. Hydrate each lift in place with distilled water prior to the addition of the next lift to help ensure an effective seal above the monitoring point. If multiple stainless-steel deep soil vapor points are being installed in the same borehole, repeat steps (c) through (h), as necessary.

(i) Seal the remaining well annulus using grout/Portland cement mix, or similar, from approximately 1 to 2 ft. bgs.

(j) Cover and protect the sampling point by installing a 4 to 8-inch flush-mount well cover.

(k) Excavate an area around the borehole as needed to facilitate the installation of the flush-mount well cover.

(l) Open the flush-mount well cover. Being careful not to pull or otherwise disturb the sampling point, extend the sample collection tubing through the center of the flush-mount well cover and place the flush-mount well cover around the sampling point.

(m) The flush-mount well cover should be finished consistent with methods used for flush-mount groundwater monitoring well installations. The protective steel “skirt” should extend approximately 1 foot below the top of the road box. As many flush-mounted vapor points are installed in paved areas, the concrete used to set the flush-mount well cover should be compatible with the bearing capacity of the existing pavement. Depending on location considerations, the concrete may be sloped slightly away from the sampling point or completed truly flush with the surroundings. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole so water that accumulates in the road box will drain. The pad should be sufficiently large to withstand anticipated traffic and weather conditions.

(n) Cut excess tubing and install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, refer to Section 2.1.4, Step f and Photograph 5 for assembly description.

(o) Verify sample port is closed and close flush-mount well cover. Clean work area.

(p) Sampling points should be permanently marked with the sampling point identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized.

(q) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(r) After vapor point installation, allow sub-surface conditions to stabilize prior to sampling. EPA typically recommends two hours for equilibration; however, the appropriate regulatory guidance associated with the project should be reviewed.

2.1.6 Installation of a Temporary Deep Soil Vapor Point

This subsection describes the procedure for installing a temporary deep soil vapor point. Unlike sub-slab sampling points, deep sampling points may be located at interior or exterior locations.

Installation: Temporary Deep Soil Vapor Point

(a) Select drilling location. Verify the utilities have been marked and ensure location is located safely away from subsurface utilities. Hand dig, if appropriate, for utility clearance purposes.

(b) Use direct push drilling technologies (e.g., Geoprobe®) to advance a borehole to 3-inches below the target sampling depth.

(c) Install Teflon® or Teflon®-lined polyethylene tubing through Geoprobe® rods to the target sampling depth. Ensure the tubing is long enough to pass through an inert gas containment structure (if required for leak-testing) and connect to a sampling canister.

(d) Carefully create a filter pack using clean sand to approximately 6-inches above the end of the tubing, backfilling the deep soil vapor point through the Geoprobe® rods if possible.

(e) Slowly remove rods, being careful not to pull or otherwise disturb the tubing. Use a clean measuring tape to verify that the height of the filter pack remains at least 6-inches above the end of the tubing. Add additional filter pack material as appropriate.

(f) Seal the well annulus using granular bentonite from the top of the filter pack to a depth of approximately 1 ft. bgs. Place granular bentonite above the filter pack material in 3 to 6-inch lifts. Hydrate each lift in place with distilled water prior to the addition of the next lift to help ensure an effective seal above the monitoring point.

(g) Cut excess tubing and install stopcock, or equivalent, on sample tubing to close the sample point. If materials listed in Section 1.3 are used, refer to Section 2.1.4, Step f and Photograph 5 for assembly description.

(h) Record sample point construction details as outlined in Section 5.1. Details should be sufficient to document that appropriate materials/procedures were used during construction and to calculate the purge volume as described in Section 2.2.3. An example field form is provided in Attachment C.

(i) After the vapor point has been installed, adequate time should be allowed for the subsurface to return to equilibrium conditions. The equilibration time will be dependent on the degree of soil disturbance during installation and regulatory requirements. The Project Manager should be consulted to determine the optimal/required equilibration time. Photograph 8 is a picture of a temporary deep soil vapor sampling point at an exterior location.

NOTE: As an alternative to installing temporary deep soil gas points as described above, soil gas samples can be collected in real time during drilling activities using specialty tooling such as the Geoprobe® post-run tubing (PRT) system. Additional information regarding the means and methods of using specialty tooling is available through vendor websites. If using an alternative installation method, the best practices outlined in this SOP should be considered. For example, if collecting samples through reusable tooling, such as the PRT system, care should be taken to ensure equipment is decontaminated between sample locations. Additionally care should be taken to ensure subcontractors do not use materials that may contain VOCs during installation of the temporary sampling point.

Decommission: Temporary Deep Soil Vapor Sampling Point

After sample collection is complete, decommission temporary sampling point as described below.

(a) Remove the tubing from the boring.

(b) Abandon vapor point boring with non-shrinking grout or cement, or other material consistent with surface conditions.

(c) Clean up the work area.

2.2 Active Soil Vapor Sample Collection

2.2.1 Pre-sampling Activities

Pre-sampling activities include, but are not limited to the following:

- Determine the analyses and reporting limits required prior to sampling and communicate with the analytical laboratory. If low reporting limits are required, then the sampling canister may need to be prepared by the laboratory for analysis via SIM or low-level analysis. If SIM analysis is required, it is recommended that each sampling canister be individually certified as clean.
- Determine the size of the sampling canister required and desired flow controller setting (100 to 200 mL per minute is common for soil vapor sampling). Typically 1-liter or smaller canisters are used. Six-liter canisters are often required to achieve the desired reporting limits for indoor air sampling. However smaller sample canisters are typically sufficient to achieve the desired reporting limits for active soil vapor sampling. Six liter canisters are very cumbersome to use and expensive to ship. Additionally 6-liter canisters take longer to fill, and due to the sample

volume, are more likely to exhibit leaks (ambient air short-circuiting) particularly in lower permeability soils.

- Discuss project requirements for leak testing with the Project Manager. Acquire and assemble materials required for applicable leak detection testing, e.g., helium, inert gas containment device, sealing material for quantitative tracer testing.
- Verify that the laboratory analyte list includes the tracer, e.g., 1,1-difluoroethane or helium, if appropriate.
- Order and receive sampling canisters, flow controllers, and duplicate tees from the laboratory. A minimum 2-week lead time is recommended. Because sample canisters are re-used and expensive, laboratory stock is limited. For large projects or for projects in which individually-certified canisters are required, a longer lead time may be needed for the laboratory to fulfill the canister order.
- To the extent reasonable, assemble the sample collection train in advance, e.g., moisture filter and tubing connection from sample point to flow controller. Dirt, wind, cold, etc. can make assembling an air tight sample collection train difficult in the field. Photograph 9 is an example of a pre-assembled moisture filter apparatus than can be used to quickly form a connection with the regulator (equipped with a barbed fitting) and the ¼-inch sample collection point.
- Sampling equipment should be inspected prior to sampling. Sampling equipment provided by the laboratory typically includes an analog pressure gauge on the canister and/or the flow controller. See Photographs 10, 11, and 12 for examples.
    - The vacuum of the sampling canisters should be recorded in the field prior to sampling using the analog gauge provided by the laboratory. If the vacuum is less than 25 inches of mercury (in. Hg), the sampling canister should not be used because this indicates a potential leak. The sampling canister vacuum may also be checked with a digital vacuum gauge, which can be more accurate than the analog gauges provided by the laboratory.
    - Check the documentation attached to the flow controller to verify the flow rate has been set to the correct flow rate, typically between 100 and 200 mL/min.
- Use sample point construction documentation to determine the purge volume.
- Label the tag on the sampling canister with the pertinent sampling data, as well as the flow controller number.
- A clean pair of new, non-powdered, disposable gloves should be worn each time a different location is sampled, and the gloves should be donned immediately prior to sampling. The gloves should be changed any time during sample collection when their cleanliness may be compromised.

2.2.2 Connection of Flow Controller to Sampling Canister

The connection between the soil vapor flow controller and the sampling canister is likely to vary between laboratories. Be sure to follow the laboratory-provided directions when connecting the flow controller to the sampling canister. Photographs 10, 11, and 12 show several common soil vapor flow controllers and sampling canisters. Quick connect fittings are typically simple and trouble-free, whereas compression type fittings are more common, but may also be more troublesome due to preexisting imperceptible damage, i.e., minor abrasions caused by dust/dirt and/or deformation caused by overtightening. Common suggestions for connecting the flow controller to the sampling canister using compression type fittings are as follows:

(a) Confirm the valve is closed (knob should already be tightened clockwise), before unthreading the stainless-steel plug from the top of the canister.

(b) Check to see that the O-ring is still in place prior to making the connection. Ensure extra O-rings and ferrules are shipped with the flow controller in case they are damaged or missing.

(c) If present, remove the plastic cap from the flow controller outlet (male threads) before attempting to connect to the inlet on the sampling canister.

(d) Do not over tighten compression fittings.

2.2.3 Purge Sample Collection Point

The following section describes the procedure for purging the sample collection point prior to sample collection. In order to ensure a representative sample is collected, at least one purge volume should be removed prior to inert gas testing and three purge volumes should be removed prior to sample collection. However, no more than five purge volumes should be removed prior to sample collection. Both under purging and over purging can affect the representativeness of the sample, and create a low bias. If the project scope includes field screening/measurements with a PID, FID, and/or landfill gas meter, caution should be used regarding the number of purge volumes being removed during these measurements. In order to control the potential for over purging, field screening can be completed concurrent with sample point purging (after one purge volume has been removed). Alternatively field measurements may be collected after sample collection has been completed.

(a) Calculate the volume of air in the sample point and sample collection tubing or refer to Table 1 for pre-calculated volumes for select tubing sizes.

$$V_{tubing} = (\pi r_t^2 h_t)$$

Where:

$\pi = 3.14159265$
r_t = radius of the inner diameter of tubing (inches)
h_t = length of tubing (inches)
V_{tubing} = volume of air in entire length of tubing (in^3)

Table 1: Purge Volumes for Select Tubing/Vapor Point Sizes

Tubing/Vapor Point Size (inches ID)	Volume/ft (milliliters/ft)
$^3/_{16}$	5.4
$^1/_4$	10
$^3/_8$	22
$^1/_2$	39
$^3/_4$	87
1	150
2	620
4	2,470
6	5,560
ID = Inner Diameter	

$V_{vapor\ probe} = (\pi r_{vp}^2 h_{vp})$

Where:
r_{vp} = radius of the inner diameter of vapor point (inches)
h_{vp} = length of vapor point (inches)
$V_{vapor\ probe}$ = volume of air in entire length of vapor probe (in^3)

$V_{filter\ pack\text{-}air} = \eta * [\pi r_{fp}^2 h_{fp} - V_{vapor\ probe}]$

Where:
η = air-filled porosity of the filter pack (typically 0.3 to 0.4)
r_{fp} = radius of the filter pack (inches)
h_{fp} = length of the filter pack (inches) – Refer to sample point construction details
$V_{filter\ pack\text{-}air}$ = air-filled volume of the filter pack (in^3)

$V_T = V_{tubing} + V_{vapor\ probe} + V_{filter\ pack}$

Where:
V_T = Total volume of air in the sample point, e.g., tubing, sampling probe, and filter pack (if present)
Convert in^3 to mL (1 in^3 = 16.387 mL)

(b) If applicable, use an air flow rate meter (Dry Cal® or equivalent) to determine the flow rate of the purge pump. Using tubing, connect the purge pump to the outlet of the flow rate meter. The type of tubing used here is optional; the only requirement is that there is a good fit in order to obtain an accurate flow rate reading. Record the flow rate of the purge pump (mL/min). Note: For low volume sample points (e.g., sub-slab points which typically have a total volume <200 mL) a graduated 50 mL manual syringe may be used as an alternative to a purge pump.

(c) If applicable, calculate the time required to purge one purge volume based on the flow rate of the purge pump (Note: If used, the inert gas detector may also be used as the purge pump).

Where
V_T in mL (calculated above) / purge pump flow rate (mL/min) *60 seconds/1 minute = Number of seconds required to purge one purge volume

(d) Connect the purge pump or syringe to the sample collection point.

(e) Use the purge pump or syringe to purge the sample point. If applicable, remove at least one sample point volume prior to inert gas tracer testing and/or field screening/measurements. Remove at least 3 sample point volumes and no more than 5 sample point volumes prior to sample collection.

(f) Disconnect purge pump or syringe from the sample point. Immediately connect the sample collection apparatus to the sample point and proceed with leak testing and sample collection as described in Section 2.2.4 and Section 2.2.5 below.

2.2.4 Leak Testing

Leak testing is performed to verify that a representative sample is collected. Leaks may occur in the sample collection train and/or the soil vapor sample point itself. ***Leak testing to verify the integrity of both the sample collection train and the soil vapor sample point itself must be completed for every soil vapor sample in order to establish air tightness***. Leak testing of the sample collection train can be completed through a shut-in leak test. Leak testing using a tracer gas, referred to as tracer testing in this SOP, is typically used to test the integrity of the soil vapor sampling point itself, although it can also be used to test the integrity of the sampling train. Tracer testing may be either quantitative (e.g., helium) or semi-quantitative (e.g., 1,1-difluoroethane). Quantitative tracer testing is typically more difficult and labor intensive than the use of a semi-quantitative tracer. The selection of the appropriate tracer is dependent on project objectives and regulatory requirements. For example, in the State of New York, use of a quantitative tracer is required to verify the sample point integrity prior to each sampling event. For projects where state requirements do not mandate the use of a quantitative tracer, a semi-quantitative tracer may be appropriate and more cost effective. When permanent sampling points are installed, it may be appropriate to use a quantitative tracer to verify initial sample point integrity, and a semi-quantitative tracer may be used during subsequent sampling events to document that the sampling point integrity has not been compromised.

Attachment D describes recommended methods for completing leak testing to verify the integrity of the sample collection train prior to sample collection, as well as options for either semi-quantitative leak testing or quantitative leak testing to verify soil vapor sampling point integrity. Leak testing is required. However the leak-testing methods described in Attachment D are recommendations only. Actual leak test methods may vary based on project objectives and regulatory requirements.

2.2.5 Vapor Sample Collection

(a) Connect the flow controller to the canister as described in Section 2.2.2 and assemble the sample collection train. Depending on the sample set up, the sample collection train will typically include the following: the sampling canister, the flow controller, a moisture filter, a stopcock, as well as appropriate fittings and inert tubing (e.g., Teflon®, Teflon®-lined, or Nylaflow®) to connect these components. For an example, see Photograph 13. For duplicate samples a laboratory provided duplicate tee will also be included (see Photograph 14).

(b) On permanent sampling points, open/prepare the sample collection point as appropriate.

1. For permanent points protected with a road box or flush-mount well cover, open the lid to inspect the hydraulic cement or grout/Portland cement seal between the sampling point and the flush-mount well cover. Inspect seal between the concrete floor (or other surface material) and the flush-mount well cover. If the seal is visibly compromised, then place granular bentonite in the void(s) and hydrate.

2. For permanent points installed via the Stainless-steel Probe Method, remove sink hole cover (if present). Remove plug using a $^{7}/_{16}$–inch socket and thread a male/male coupling (see Photograph 2) onto the permanent point. Lock the ferrule and the nut to the sample tubing, then connect the sample tubing to the top of the coupling (do not

use a wrench; this connection should be hand tight). Inspect the seal, if visibly compromised, then place additional granular bentonite in the void and hydrate.

(c) Purge the sample collection point as described in Section 2.2.3. Remove at least one sample point volume prior to inert gas tracer testing and/or field screening/measurements. Remove at least 3 sample point volumes and no more than 5 sample point volumes prior to sample collection.

(d) If applicable, field screening/measurements with a PID, FID, and/or landfill gas meter may be collected while the sample collection point is purged.

(e) Complete project-specific leak testing as described in Section 2.2.4. Leak testing to verify the air tightness of **both** the sample collection point and the sample collection apparatus is required. Sample point integrity is tested with **either** quantitative (inert gas) tracer testing or with semi-quantitative tracer testing, not both. Quantitative (inert gas) tracer testing is typically completed immediately after purging and prior to the shut-in leak test (to verify the integrity of sample collection train). By contrast, semi-quantitative tracer testing is completed concurrent with sample collection. Detailed procedures for recommended leak test options are provided in Attachment D.

(f) During pre-sampling leak testing procedures, the sample collection apparatus should be connected to the sample collection point. Verify the integrity of this connection, and tighten as appropriate.

(g) Open the sampling canister valve to begin sampling. Record the start time, flow controller rate, initial vacuum, and sampling canister size.

(h) Depending upon the soil type, the sampling canister may fill slower than anticipated based on the flow controller setting. It is preferable to wait until the vacuum reaches no more than 6 in. Hg, rather than wait a specified time period. Note, if vacuum fails to drop, this may be the result of tight soils, cold weather, or other equipment-related issues, which may require troubleshooting. If the problem cannot be resolved, contact the Project Manager to determine how to proceed, as the canister is not filling properly and inadequate sample volume may lead to elevated reporting limits and potential issues with the representativeness of the sample. Note that the final target vacuum may vary depending on the project and regulatory requirements. Verify appropriate requirements prior to collecting samples.

(i) When the canister reaches the final target vacuum, the sampling canister valve can be closed. Record the final vacuum and time the valve was closed.

(j) Remove the tracer gas containment device.

(k) Disconnect the sample collection apparatus from the sample collection point. Dismantle apparatus, and dispose of tubing, moisture filter, etc.

(l) Close permanent sample collection points or decommission temporary sampling points.

1. On permanent sub-slab points installed via the Flush-mount Well Cover Method, verify that the ball valve is in the off (closed) position and re-install the lid to close the sample collection point.

2. On permanent sub-slab points installed via the Stainless-Steel Probe Method, remove the tubing connected to the soil vapor probe and replace the plug. Hand tighten the threads of the plug, and then tighten slightly with a $^{7}/_{16}$-inch socket. Do not over-tighten the plug, or the point may be damaged by the force of threading/unthreading the plug. Replace the sink hole cover (if present).

3. On permanent deep soil vapor points, verify that the stopcock is in the off (closed) position and re-install the lid to close the sample collection point.

4. On temporary sub-slab soil vapor sampling points, decommission the sampling point as described in Section 2.1.5.

5. On temporary deep soil vapor sampling points, decommission the sampling point as described in Section 2.1.6.

(m) Clean up the work area.

2.2.6 Post-sampling Activities

(a) Check the label on each sample.

(b) Re-install cap or plug on sample canister for shipment. Package canisters for shipment consistent with packaging upon receipt from the laboratory.

(c) Complete the chain-of-custody. Verify that the analyte list includes the tracer, if applicable.

(d) Air samples do not need to be refrigerated or shipped on ice.

(e) Ensure samples are delivered to the laboratory well before the required holding time expires.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following samples: background/ambient samples, equipment blanks, and field duplicates.

4.1 Background or Ambient Sample

A background or ambient sample is an ambient air sample collected outside in the area proximate to the site. Analysis of the background or ambient sample can provide information about the ambient levels of site contaminants.

4.2 Equipment Blank

An equipment or material blank may be used to provide information about the levels of contaminants present in materials used to collect soil vapor. An equipment blank is collected by pulling ambient air through a constructed soil vapor probe and all relevant components of the soil collection train (e.g., moisture filter, tubing, etc.) prior to installation. If an equipment blank is collected, a background or ambient air sample, described in Section 4.1 above, must also be collected so that contaminants attributable to the sample point may be distinguished from contaminants present in ambient air.

4.3 Field Duplicates

The following procedures should be used for collecting field duplicates of soil vapor samples:

(a) For quality control purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a non-existing sample identification will be assigned in labeling the duplicate. Labeling procedures used for sampling will be employed, and all parameters measured will also be recorded. Since the duplicate is collected simultaneously with the actual sample, a "blind" sample time, typically within 1 hour of the actual time, will also be assigned. The actual source and collection time of the duplicate sample will be recorded in the field book.

(b) Each duplicate sample will be collected by installing a T-connection (made of Teflon®, stainless-steel, or brass) at the end of the sample tubing and connecting one sampling canister to each side of the connector. Both sampling canister valves must be opened and closed at the same time. Photograph 15 is a picture of a duplicate sample being collected. Typically duplicate tees can be provided by the analytical laboratory upon request (Photograph 14).

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

5.1 Sample Point Installation

Record the general sample point installation information in the field book or on a field form. An example field form is provided in Attachment C. At a minimum, field documentation must include the following information:

- Sample point identification number
- Sample location (sketch of the sample point)
- Date/time of installation
- Technician(s) names, including subcontractors
- Slab thickness, if applicable
- Construction details including the following:
    - Installation method
    - Diameter and depth of borehole
    - Composition of probe, sealing, and finishing materials (to document that inert, VOC-free materials were used)
    - Material size including diameter and length/thickness (to allow purge volume to be calculated)
- Field screening results, if applicable
- Decontamination procedure, if applicable
- Presence of any materials that may interfere with soil vapor results

Representative tasks and the condition of areas within the area where soil vapor points are installed should be photographed.

5.2 Sample Collection

Record the general sample collection information, such as location, identification, and date/time in the field book or on a field form. Typical field documentation recorded in a field book may include the following information:

- Sampling canister ID
- Flow controller ID
- Initial vacuum
- Final vacuum
- Sample identification number
- Sample location (sketch of the sample point)
- Leak-test method(s) and applicable data associated with leak-testing, e.g., tracer used, final inert gas concentration detected in sample tubing, etc.
- Time and date sample collection started
- Time and date sample collection ended
- Personnel performing the task
- Volume of vapor purged prior to sampling
- Flow rate of purge pump and flow controller, if applicable
- Weather conditions during sampling
- Field screening results, if applicable
- Decontamination procedure, if applicable
- Analytical parameters
- Heating and air conditioning systems in use at the facility at the time of sampling (e.g., type of system, primary fuel, location of boiler/furnace, type of air conditioning, and air distribution system)
- Barometric pressure at sample collection start

- Barometric pressure at sample collection end
- Presence of any materials that may interfere with soil vapor results

Representative tasks and the condition of areas within the area where soil vapor sampling is performed should be photographed.

All sample numbers must be documented on the chain-of-custody form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

H&P Mobile Geochemistry, Inc., 2013. Evaluation of Leak Check Procedures for Soil Vapor Sampling. Presented at AEHS in San Diego, California on March 20, 2013.

NYSDOH, 2006. Guidance for Evaluating Soil Vapor Intrusion in the State of New York, New York State Department of Health. October 2006.

USEPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples. EPA/600/R-05/147. March 2006.

USEPA, 2007. Construction and Installation of Permanent Sub-slab Soil Gas Wells. SOP 2082. March 29, 2007.

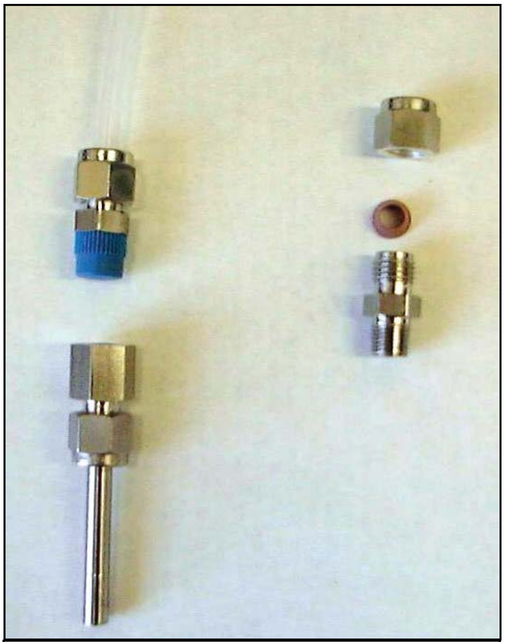
USEPA, 2015. OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, EPA OSWER Publication 9200.2-154. June 2015.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JULY 2016	NOT APPLICABLE
1	AUGUST 2017	MADE CORRECTION IN TABLE 1 AND FIGURE B-2

Attachment A: Photographs

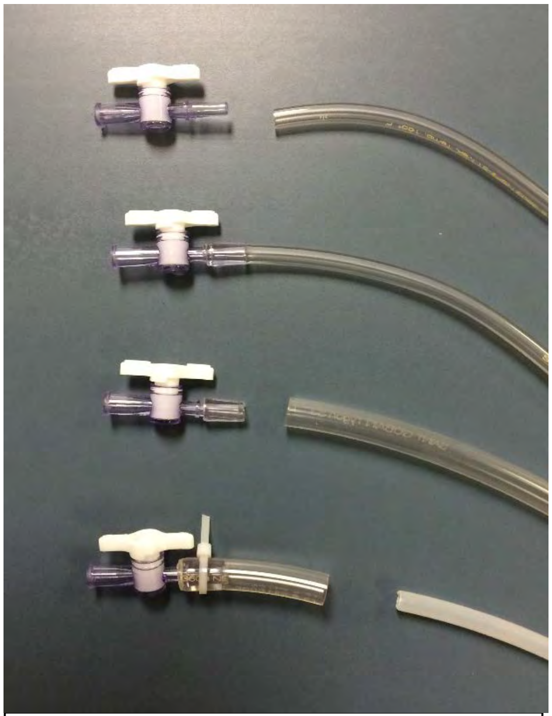
Photograph 1 - Overhead view of completed point via Flush-mount Well Cover Method



Photograph 2 - Stainless-steel Probe Method components

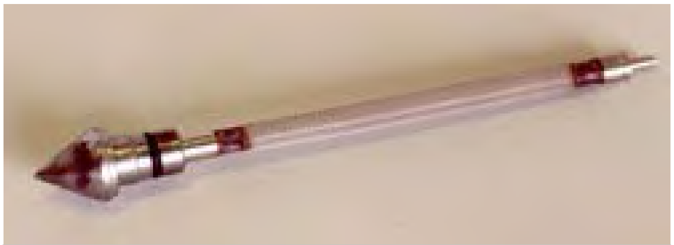
Photograph 3 – Rotary hammer drill

Photograph 4 - Plug and fitting on stainless-steel probe before installation of cement seal



Photograph 5 – Step-by-step process for assembling the end of a deep or temporary sampling point

Photograph 6 – Sample collection at temporary sub-slab vapor point



Photograph 7 – Stainless-steel mesh soil vapor point

Photograph 8 – Soil gas sampling set up at deep, exterior temporary soil vapor point

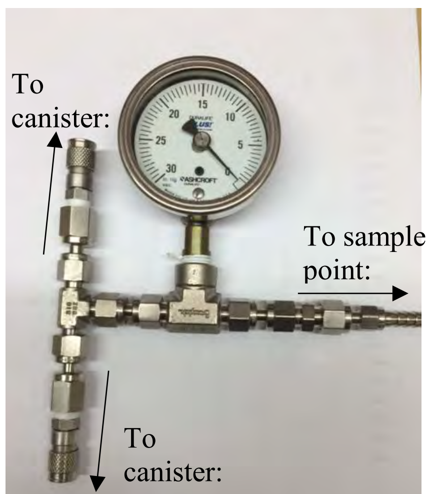
Photograph 9 – Inline moisture filter and stopcock assembly (See Photograph 13, Item [C])

Photograph 10 – One-liter sampling canister with quick connect fitting (See Photograph 13, Item [A])

Photograph 11 – Flow controller with quick connect fitting to canister and barbed fitting to vapor point (See Photograph 13, Item [B])

Photograph 12 - Flow Controller and Sampling Canister
Flow controller (top) with inlet at top and outlet at base. Sampling Canister (bottom) with inlet at top. Note inverted nut at inlet of canister which threads onto flow controller outlet.

Photograph 13 – Soil gas sample collection set up at deep soil gas vapor point prior to placement of shroud for tracer testing.



Photograph 14 – Duplicate tee with quick connect fittings

Photograph 15 - Field duplicate sample collection setup

Photograph 16 - MGD-2002 Helium detector

Photograph 17 - T-connection for quantitative tracer gas testing

Photograph 18 – Exterior soil gas sampling point with moisture filter setup to begin shut-in leak test

Photograph 19 - Soil gas sampling set up with semi-quantitative leak testing applied via rags draped over vapor point and sampling apparatus.
Note: Although rags are placed around fittings here, a single rag placed immediately adjacent to the sampling apparatus is sufficient when using the Rag Method to apply a semi-quantitative tracer.

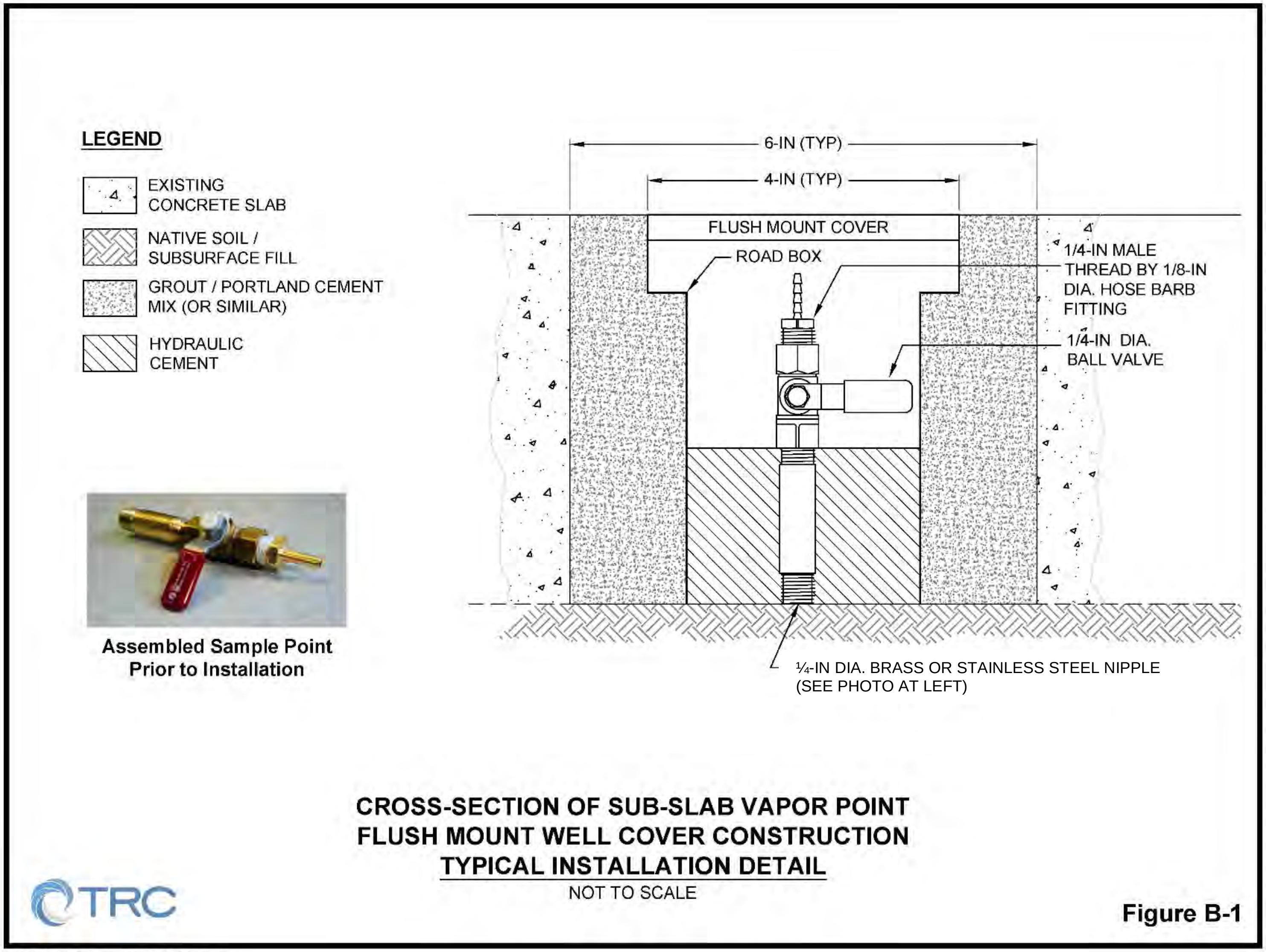
Photograph 20 – Soil gas sample collection set up at deep soil gas vapor point with shroud to contain 1,1-difluoroethane tracer during sample collection.

Photograph 21 - Plastic wrap leak detection method during sampling

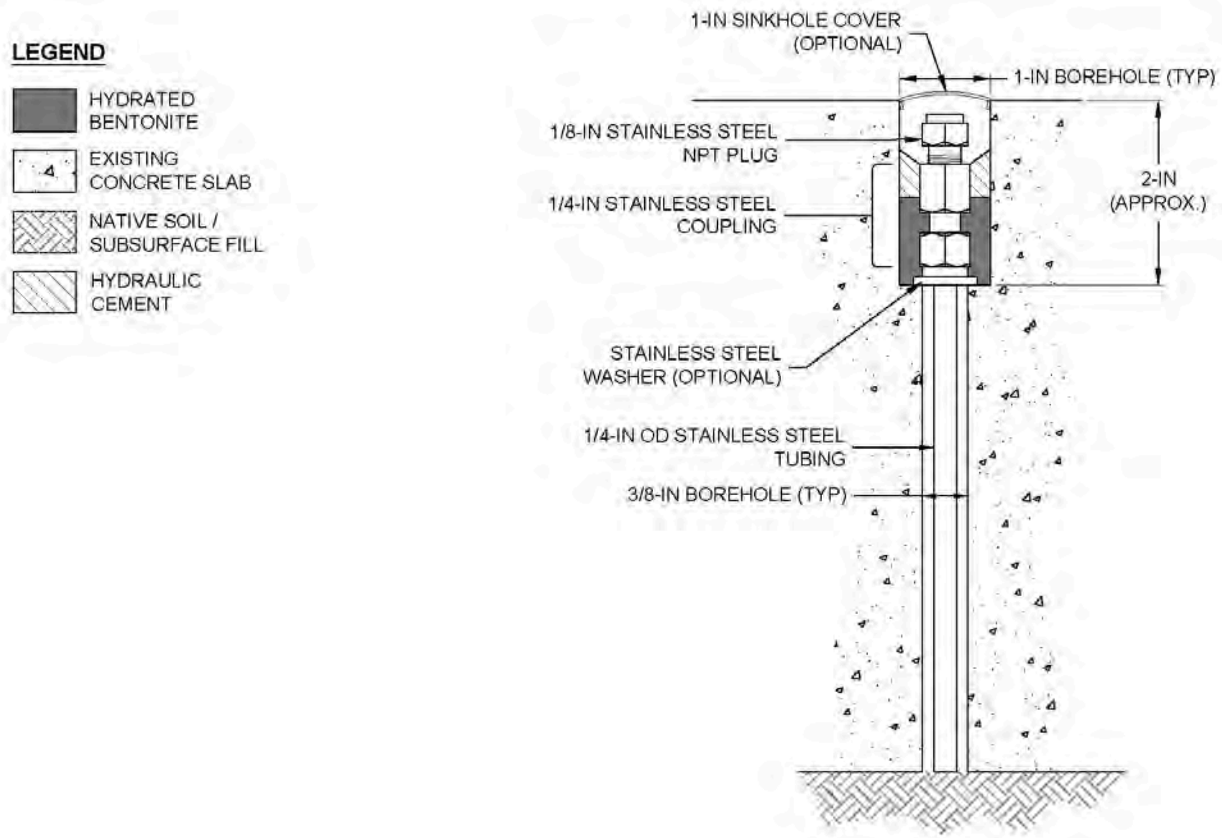
Photograph 22 - Inverted container leak detection method with helium tank in background (right). Leak detection for vapor point only, canister outside of container.

Photograph 23 - Inverted container leak detection method with canister inside of container. Leak detection for vapor point and sample collection apparatus. Helium tank to the left of container.

Attachment B:
Soil Vapor Point Cross-Sectional Diagrams



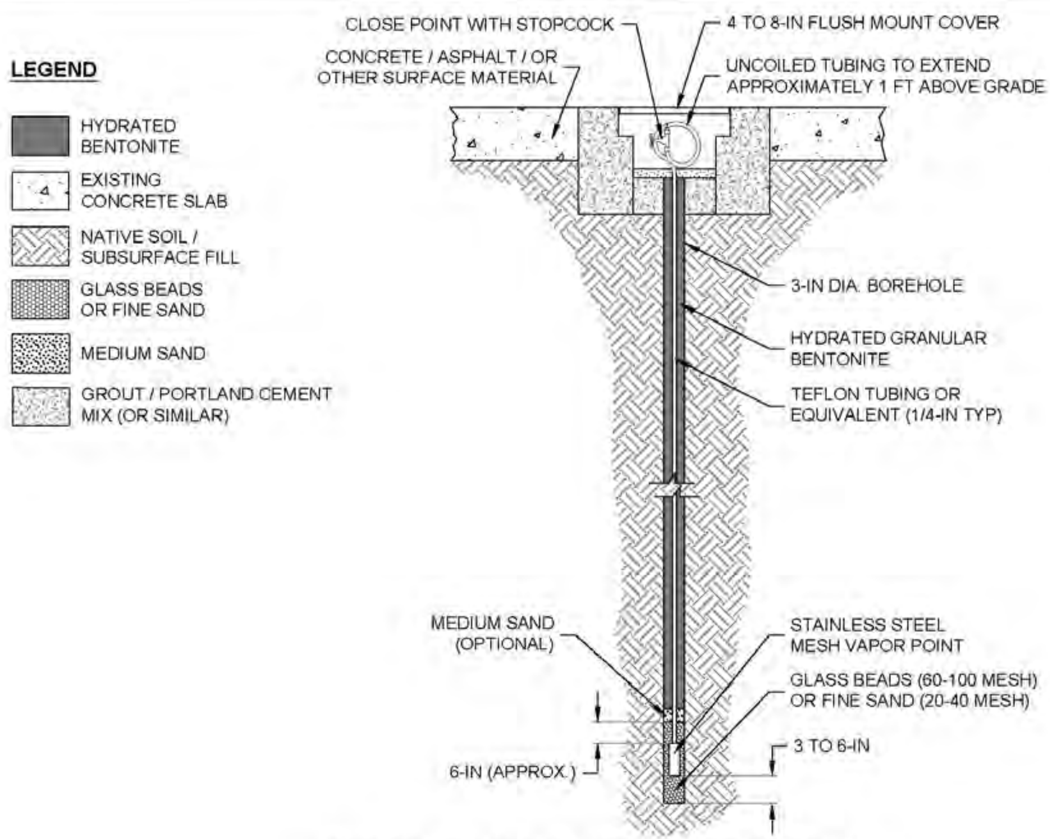
J:\PM SMetz_Soil Gas SOP\SG SOP Figs.dwg



CROSS-SECTION OF SUB-SLAB VAPOR POINT
PERMANENT STAINLESS STEEL PROBE CONSTRUCTION
TYPICAL INSTALLATION DETAIL
NOT TO SCALE

Figure B-2

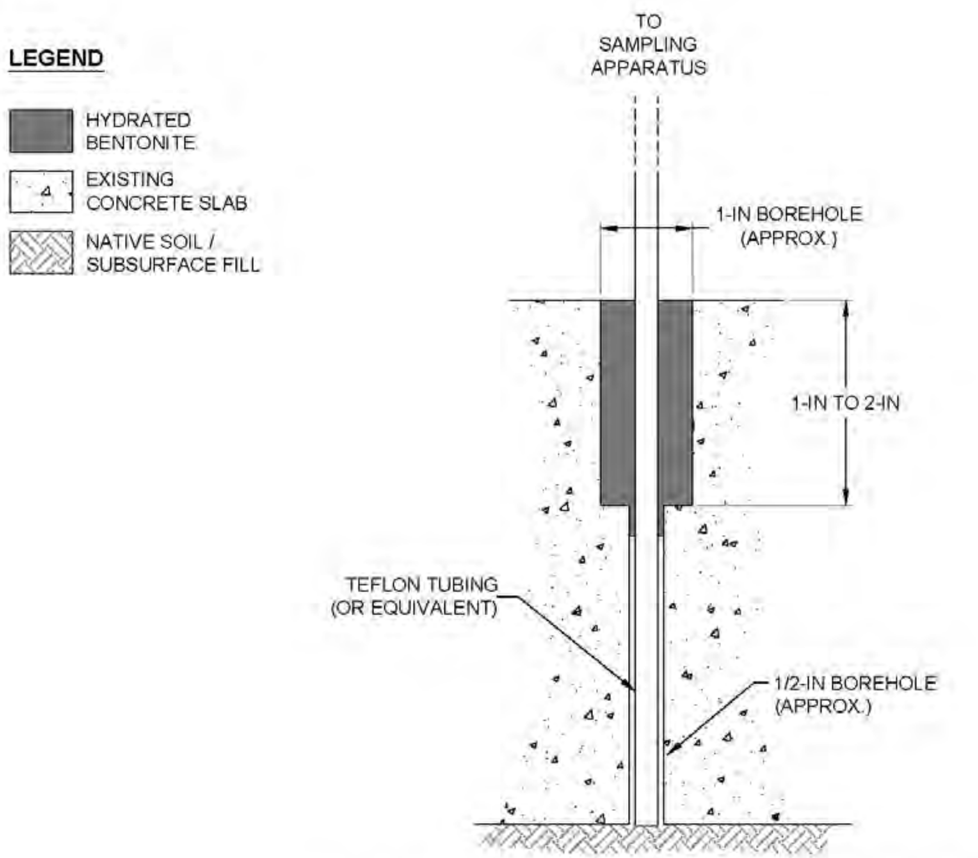
J:\PM Smetz_Soil Gas SOP\SG SOP Figs.dwg



CROSS-SECTION OF DEEP VAPOR POINT PERMANENT CONSTRUCTION TYPICAL INSTALLATION DETAIL

NOT TO SCALE

Figure B-3



CROSS-SECTION OF SUB-SLAB VAPOR POINT
TEMPORARY LOCATION CONSTRUCTION
TYPICAL INSTALLATION DETAIL
NOT TO SCALE

Figure B-4

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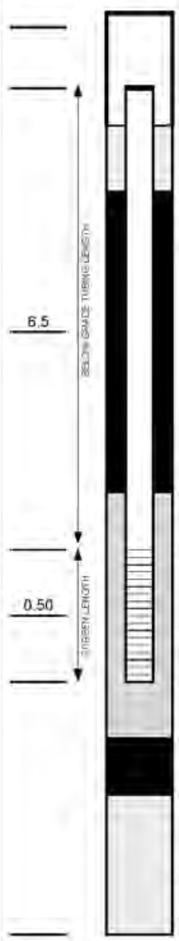
Attachment C:
Soil Vapor Point Installation and Sampling Field Forms

SOIL GAS SAMPLE POINT CONSTRUCTION DIAGRAM

PROJ. NAME: EXAMPLE FORM		POINT ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:	CHECKED BY:

ELEVATION (BENCHMARK: USGS) | DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)



0.0 GROUND SURFACE

0.5 TOP OF SURFACE PLUG

1.0 BOTTOM OF SURFACE PLUG

SURFACE PLUG MATERIAL
CEMENT

SEAL MATERIAL
GRANULAR BENTONITE

6.0 BENTONITE SEAL

6.5 TOP OF SCREEN

FILTER PACK MATERIAL
GLASS BEADS

7.0 BOTTOM OF SCREEN

7.5 BOTTOM OF FILTER PACK

NA BENTONITE PLUG

BACKFILL MATERIAL
NA

7.5 HOLE BOTTOM

SAMPLE POINT DETAILS

MATERIAL: TEFLON TUBING

TUBING SIZE: 1/4" OD

SCREEN TYPE: 6" STAINLESS STEEL IMPLANT

SCREEN MATERIAL WIRE MESH

BOREHOLE DIAMETER: 3 IN. FROM 0 TO 7.5 FT

SURF. CASING DIAMETER: 4 IN. FROM 0 TO 8 IN.

SUBSURFACE CONDITIONS:

Concrete is 8-inches thick.

Subase is fill composed of gravel, sand and silt

CONSTRUCTION NOTES:

Tubing extends 18-inches above grade to facilitate connection to sampling canister.

Sample point finished with a polyethylene stop cock to close sample point.

PROTECTIVE COVER DETAILS

PERMANENT, LEGIBLE LABEL ADDED? ☑ YES ☐ NO
PROTECTIVE COVER INSTALLED? ☑ YES ☐ NO

REVISED 03/2016

RECORD OF VAPOR SAMPLING

Date__________________________ **Project Number**________________________

Project Name__________________________ **Field Personnel**________________________

Probe ID__________________________ **Probe Depth**________________________

Drilling Contractor__________________________ **Weather**________________________

Shut In Test

Test Start Time (HH:MM:SS)________________ **Vacuum at Start**____________________

Test Stop Time________________________ **Vacuum at End**______________ **Pass?**____________

QUANTIATIVE (HELIUM) TRACER TEST (Shroud)

Note: Perform helium or semi-quantitative tracer test

Test	Time	Helium Concentration	Units (% or ppm_v)	Notes
Shroud Atmosphere				
Sampling Train				

Helium concentration within sampling train should be less than 10% of shroud atmosphere concentration.
If seal or probe needs to be reset then record 2nd attempt below.

Retest (if applicable)	Time	Helium Concentration	Units (% or ppm_v)	Notes
Shroud Atmosphere				
Sampling Train				

SEMI-QUANTITATIVE TRACER TEST

Note: Perform helium or semi-quantitative tracer test

Tracer Type (DFA or Isopropyl)______________ **Method (Rag or Container)**________________________

Location of Tracer (On or Adjacent to Sampling Apparatus)________________ **Completed?**___________

VAPOR PURGING CALCULATION

Sub-Slab Point

ONE PURGE VOLUME (mL) = $V_T + V_P$

WHERE $V_T = (3.14 * R_T^2 * H_T)$

AND $V_P = (3.14 * R_p^2 * H_P)$

Soil Gas Point

ONE PURGE VOLUME (mL) = $V_T + V_P + V_{FP}$

WHERE $V_T = (3.14 * R_T^2 * H_T)$

AND $V_P = (3.14 * R_p^2 * H_P)$

AND $V_{FP} = \eta * [3.14 * R_{fp}^2 * H_{fp} - V_p]$

****KEEP UNITS OF LENGTH CONSISTENT, USE CM (1 CM^3 = 1 ML) OR TO CONVERT IN^3 TO ML MULTIPLY BY 16.39****

V – Volume of air in mL (V_T – in tubing; V_p – in probe, V_{FP} – in filter pack)
R – Radius (V_T – of tubing; R_p – of inner diameter of point, R_{FP} – of outer diameter of filter pack)
H – Height (H_p – of vapor point, H_{FP} – of filter pack)
cm – centimeter; mL – milliliter; in - inches
η – air-filled porosity of the filter pack (typically 0.3 to 0.4)

Purge Rate (mL/min)________________________ **One Purge Volume (mL)**________________________

Purge Time (min)________________________ **Total Volume Purged (mL)**________________________
Refer to Table 1 in the SOP document for guidance determining volumes of various tubing and probe diameters.
Purge 2-5 purge volumes prior to sample collection (if applicable complete purging during inert gas readings).

VAPOR SAMPLING

Canister I.D.____________________ **Flow Controller I.D.**______________________________

Start Time____________________ **Initial Vacuum Pressure in Sample Canister**________________in Hg

Stop Time____________________ **Final Vacuum Pressure in Sample Canister**________________in Hg

Sample I.D.____________________ **Laboratory**______________________________

Attachment D:
Detailed Leak Testing Procedures

D.1 Overview

Leak testing is performed to verify that a representative sample is collected. Leaks may occur in the sample collection train and/or the soil vapor sample point itself. ***Leak testing to verify the integrity of both the sample collection train and the soil vapor sample point itself must be completed for every sub-slab vapor sample in order to establish air tightness***. Leak testing of the sample collection train can be completed through a shut-in leak test. Leak testing using a tracer gas, referred to as tracer testing in this SOP, is typically used to test the integrity of the soil vapor sampling point itself, although it can also be used to test the integrity of the sampling train. Tracer testing may be either quantitative (e.g., helium) or semi-quantitative (e.g., 1,1-difluoroethane). Quantitative tracer testing is typically more difficult and labor intensive than the use of a semi-quantitative tracer. The selection of the appropriate tracer is dependent on project objectives and regulatory requirements. For example in the State of New York, use of a quantitative tracer is required to verify the sample point integrity prior to each sampling event. For projects where state requirements do not mandate the use of a quantitative tracer, a semi- quantitative tracer may be appropriate and more cost effective. When permanent sampling points are installed, it may be appropriate to use a quantitative tracer to verify initial sample point integrity, and a semi-quantitative tracer may be used during subsequent sampling events to document that the sampling point integrity has not been compromised.

This attachment describes recommended methods for completing leak testing to verify the integrity of the sample collection train prior to sample collection, as well as options for either semi-quantitative leak testing or quantitative leak testing to verify soil vapor sampling point integrity. However the leak-testing methods described in this section are recommendations only. **Actual leak test methods may vary based on project objectives and regulatory requirements.**

D.2 Equipment for Leak-Testing

Shut-In Leak Test:

- Assembled sample collection train, including sampling canister, flow controller, and all other components necessary for sample collection. See Section 2.2.2 of this SOP.
- Stopcock or ball valve (may be part of sample collection train or sample collection point) to close sample collection train
- Vacuum gauge (typically an integral component of the sampling canister and/or the flow controller)
- Zip ties
- Wrenches or other tools necessary to tighten fittings
- Teflon tape (not to be used with compression fittings)
- Watch or timer (capable of monitoring time to the nearest second)

Semi-Quantitative (Inert Gas) Tracer Gas Testing:

- Assembled sample collection train, including sampling canister, flow controller, and all other components necessary for sample collection. See Section 2.2.2 of this SOP.
- Tracer (1,1-difluoroethane [electronic dusting spray, verify composition prior to use] is recommended; isopropyl alcohol may also be used)
- Rag (for rag method)
- Ziploc bag (for rag method)
- Large clear plastic bags (often marketed as recycling bags) (for container method)

- Weight(s) or similar to weigh down plastic bag (for container method)
- Duct tape (for container method)
- Paper towels (for container method)
- Distilled water (for container method)

Quantitative (Inert Gas) Tracer Gas Testing:

- Inert gas detector (e.g., Radiodetection® MGD-2002 for helium – See Photograph 16)
- Air flow meter (e.g., DryCal® DC-Lite)
- Polyethylene tubing to transfer inert gas to containment structure
- Stainless-steel T-connector with associated fittings for tubing (optional) – See Photograph 17
  - One – $^1/_4$-inch OD stainless-steel tee
  - Two – $^1/_4$-inch OD stainless-steel port connector
  - Five – $^1/_4$-inch stainless-steel nut and ferrule
  - One – $^1/_4$-inch OD stainless-steel ball valve
- Tubing and fittings necessary to form an air-tight connection between the inert gas detector and the sample collection port
- Wrenches or other tools necessary to tighten fittings
- Teflon® tape (not to be used with compression fittings)
- Zip ties
- High purity or ultra-high purity inert gas (e.g., helium) with tank regulator
- Tracer gas containment:
  - Plastic or stainless-steel container or
  - Plastic wrap
- Granular bentonite
- Drill and bits (if inverted container is used)
- Distilled water
- Paper towels
- Weather-stripping (if inverted container is used)
- Duct tape

D.3 Leak Test to Verify Air Tightness of Sample Collection Train, i.e., Shut-In Leak Test

Leak testing to verify the integrity of the sample collection train is required. This section describes a shut-in test, which is recommended to meet this objective. The shut-in leak test should include all fittings and connections between the sample canister and the sample port, including the moisture filter. Note, if the entire sample collection train is enclosed in the tracer containment device, tracer testing (described below) may also be used to verify the integrity of the sample collection train. The shut-in leak test is recommended because it allows the integrity of the sample collection train to be verified prior to sample collection and analysis.

a. Connect the flow controller to the canister, as described in Section 2.2.2.
b. Connect the moisture filter, if used, and any other necessary sampling components as described in Section 2.2.5(a).
c. Check all fittings and connections. With the exception of compression fittings, use Teflon® tape on threaded fittings and zip ties to help ensure tube-in-tube and barbed fitting connections are air-tight.

d. Purge sample collection point as described in Section 2.2.3, and immediately connect the sampling apparatus to the soil vapor sample point (or tee connection for quantitative tracer, see below, if applicable). Cover the end of the tubing when changing the tubing over so ambient air does not enter the sample tubing.
e. If applicable, complete quantitative (inert gas) tracer gas testing as described in Section D.5 below.
f. Verify that the stopcock, ball valve or tee on the sampling point is closed. If the sample point does not have a stopcock (or equivalent), include a stopcock in the sample collection train as near as possible to the soil collection point, so that that flow between the soil vapor sampling point and sample canister can be interrupted, yet the air tightness of all other fittings and connections is tested by the shut-in leak test (Photograph 18).
g. Note the initial vacuum (It should be 0 if the vacuum gauge is on the flow controller, or it should be between 25 and 29 inches Hg if the vacuum gauge is on the sample canister itself).
h. Open the valve on the canister. Record the initial vacuum and time. If the vacuum gauge is on the flow controller, the vacuum reading on the gauge should immediately increase to between 25 and 29 inches Hg. If the vacuum gauge is on the sample canister, the vacuum reading on the gauge may decrease slightly (<1 inches Hg) as air in the sample collection train enters the canister.
i. If any of the fittings are not air-tight, there will be a noticeable reduction in the vacuum reading when compared to the initial vacuum reading. If the fittings are air-tight, the vacuum will not change.
j. Monitor the vacuum reading for period of time sufficient to observe a noticeable drop in vacuum, e.g., a period sufficient to fill approximately 10 to 20-percent of the canister. This period will vary depending on the size of the sample canister and the flow controller setting. One minute is sufficient for a 1-liter canister paired with a 200 mL/min flow controller. The duration of the shut-in test should increase if the canister size is larger and/or if the flow rate is lower.
k. If the vacuum does not change, the sampling apparatus has passed the shut-in test. If the vacuum does change, the sampling apparatus has failed the shut-in test; check fittings and/or repeat using a new canister.
l. After the shut-in leak test is complete, begin sample collection immediately, or close the valve on the canister until sample collection begins (e.g., during inert gas tracer testing).

D.4 Leak Test to Verify Air Tightness of Sample Collection Point – Semi-Quantitative Tracer

Leak testing to verify the integrity of the sample collection point is required. This section describes a semi-quantitative inert gas tracer test, which is one of the options recommended to meet this objective. Common semi-quantitative tracers include 1,1-difluoroethane [commercially available as electronic dusting spray] and isopropyl alcohol [commercially available as rubbing alcohol].

Field Procedures

a. Complete shut-in leak test or equivalent to verify the air-tightness of the sample collection train as described in Section D.3 above.
b. Apply tracer using one of the following methods. Note that the application method is project/site geology dependent, and should be selected on a project-by-project basis. When using the container method (described below), surface concentrations of the tracer are very high, and even a small (<1%) leak may result in a large peak in the VOC analysis. This could result in cross contamination of equipment during analysis or unnecessary sample

dilution (elevated reporting limits). However, using the rag method, the tracer is not persistent over time. Therefore use of the container method may be more appropriate when the sample collection time exceeds 10 minutes.

- Rag Method
    i. Place rag in a clean resealable bag (e.g., Ziploc). Apply tracer to the rag by spraying 1,1-difluoroethane (electronic dusting spray, verify composition prior to use) to fill the inside the bag or if using isopropyl alcohol, pour a small volume of tracer onto the rag (<10 mL).

    ii. Seal the bag and agitate for a few seconds to allow the tracer to be fully absorbed into the rag.

    iii. Place the rag around the sampling apparatus. Rag can be dumped from the bag onto the ground next to the sampling point to limit contact with the saturated rag and minimize the potential for contamination of sampling equipment with the tracer (Photograph 19).

  Note that tracer may be reapplied to the same rag at each sampling point. However use extreme care when handling tracer-soaked rag and bag to minimize the potential from false positives due to contamination of sampling equipment. Contain rag in an air-tight bag between uses to prevent volatilization into field vehicle. Change gloves immediately after handling rag. Never touch sampling equipment with gloves that could be contaminated with tracer.

- Container Method
    i. To the extent feasible, prepare the surface around the sample point so that a seal between the surface and the containment device can be formed. For example, wipe down the floor with a wet paper towel in the vicinity of the sampling location and allow the floor to dry.

    ii. Use a clear plastic bag to contain the sample collection apparatus and sample collection point. Note a new plastic bag should be used for each sample to reduce the likelihood for residual tracer contamination of the sampling assembly and potential false positives.

    iii. If using 1,1-difluorethane as the tracer skip to Step iv below. If using isopropyl alcohol, wet a small section of paper towel (<10 mL) and place the wetted paper towel inside the bag. Be sure the towel is placed next to, not in direct contact with, the sampling apparatus.

    iv. Close and seal containment apparatus. Use duct tape and/or weights to form the best seal possible for the surface around the sample collection point (Photograph 20).

    v. If using isopropyl alcohol as the tracer, skip this step. Spray 1,1-difluorethane (electronic dusting spray, verify composition prior to use) into the inside of the containment apparatus through a small hole in the plastic bag. Be sure that spray is directed into the plastic bag and not onto the sample collection train itself.

c. Immediately proceed with sample collection as described in Section 2.2.5 of the SOP.

d. Verify that analysis of the tracer is included in the analyte list.

Data Evaluation
The concentration of the leak test tracer compound is determined by the analytical laboratory with other concentration data. Detection of the leak test compound does not automatically indicate that a significant leak occurred. Vapor intrusion guidance for many states provides thresholds for acceptable leaks. If applicable regulatory guidance does not specify otherwise, a leak threshold of 10-percent is typically recommended. Expected surface air concentrations of common tracers (both 1,1-difluorethane and isopropyl alcohol) based on application method are listed below:

Application Method	Approximate Surface Concentration	Target Tracer Concentration*
Rag Method	1,000,000 ug/m^3	<100,000 ug/m^3
Container Method	1,000,000,000 ug/m^3	<100,000,000 ug/m^3

*Tabulated target tracer concentration is based on an acceptable leak threshold of 10-percent. The actual target tracer concentration may vary based on applicable regulatory guidance.
Source: H&P Mobile Geochemistry, 2013. *Evaluation of Leak Check Procedures for Soil Vapor Sampling*.

Using these approximate surface concentrations as a guide, concentrations which exceed the project-specific leak threshold, indicate that sample data are suspect, and the Project Manager should be contacted to determine appropriate corrective action, e.g., data qualification, resampling, repair/replacement of the sample collection point, etc.

D.5 Leak Test to Verify Air Tightness of Sampling Point – Quantitative Tracer

Leak testing to verify the integrity of the sample collection point is required. This section describes a quantitative inert gas tracer test, which is one of the options recommended to meet this objective.

a. Use an air flow rate meter (Dry Cal® or equivalent) to determine the flow rate of the inert gas detector.
   i. Using tubing, connect the inert gas detector probe to the outlet of the flow rate meter. The type of tubing used here is optional; the only requirement is that there is a good fit in order to obtain an accurate flow rate reading. Record the flow rate of the inert gas detector (mL/min).

b. Calibrate the inert gas detector according to the manufacturer's recommendations.
c. If used, install a T-connection. The T-connection, such as that shown in Photograph 17, connects the sample point to both the inert gas detector (which may also be used to double as the purge pump) and the sampling canister, allowing flow from the sample point to be switched from the inert gas detector to the sampling canister without the introduction of ambient air. In order to assemble a stainless-steel T-connector with the parts listed in Section D.2, follow the procedures below:
   i. Cut a 1-foot long section of disposable tubing and attach to the down-flow side of the ball valve. Lock the tubing by closing the $^1/_4$-inch nut to be finger-tight, then

turn the nut with a wrench approximately 45 degrees in a clockwise direction. Check to ensure that the tubing is firmly attached to the ball valve.

ii. If not already attached, attach nuts with ferrules to each side of the $^{1}/_{4}$-inch tee. Install a $^{1}/_{4}$-inch OD port connector between the tee and the ball valve. Tighten both nuts approximately 45 degrees in a clockwise direction to lock the tee and the ball valve together.

iii. Install one nut and a port connector to the base of the tee. The connection between the connector and the tee will need a ferrule, but the connection between the connector and the sampling canister will not.

iv. Components can be field screened for leaks by placing the assembly into water and passing air through the components.

v. At the time of sampling, attach the sample tubing to the one remaining open port in the tee. Lock the tubing by closing the $^{1}/_{4}$-inch nut to be finger-tight, then turning the nut with a wrench approximately 45 degrees in a clockwise direction.

vi. At the time of sampling, connect the base of the tee with the port connector to the top of the sample collection train.

vii. Install the inert gas containment system using either the plastic wrap method or inverted container method as described below:

D.5.1 Plastic Wrap Method (for smooth interior surfaces only)

a. Wipe down floor with a wet paper towel in the vicinity of the sampling location to ensure a good seal and allow the floor to dry.

b. Allocate an approximately 2-foot by 2-foot section of plastic wrap and push the sample tubing through the center of the plastic wrap. The plastic wrap should form tightly to the tubing.

c. Connect the sample collection train with Teflon® or Teflon®-lined tubing to the vapor point as described in Section 2.2.5 of the SOP.

d. Slide the plastic wrap down the tubing until it reaches the floor.

e. Place the polyethylene tubing from the inert gas source under the plastic wrap. Attach the plastic wrap to the floor with duct tape or equivalent. If necessary, use a small piece of duct tape to secure the plastic wrap seal around the sample tubing. See Photograph 21 for an example layout.

The edges of the plastic and any penetrations through the plastic should be checked with the tracer gas detector for leaks. If any leaks are found, the leaks need to be sealed prior to purging and sampling.

D.5.2 Inverted Container Method

a. Obtain a plastic container, plastic tote, or similar container large enough to cover the sampling point (Photograph 22). If tracer testing of the entire sampling apparatus is desired, the container should be large enough to fit the entire sampling apparatus (including canister) inside (Photograph 23).

b. Modify the container for tracer testing by drilling three holes in the lower end of the container, sized appropriately for commonly sized tubing:

- One hole for the inert gas supply to enter the container (using larger diameter drill bit so tubing can fit through hole):
- One hole for the sample tubing to exit the container (using larger diameter drill bit so tubing can fit through hole):

- One hole to allow the tracer gas meter to quantify the concentration in the atmosphere of the shroud (using smaller diameter drill bit).

Note a larger container may be used such that the sample canister and sample collection train is contained within the container. If so, tracer testing will also detect leaks and short-circuiting from the sample collection apparatus, not just the sample collection point.

c. Wipe down floor with a wet paper towel in the vicinity of the sampling location to ensure a good seal and allow the floor to dry.
d. Attach sample collection train to the vapor point as described in Section 2.2.5 of the SOP. If a small container is used, run the sample tubing through the container.
e. Place the container over the sample point. Wet bentonite paste, weather-stripping, or duct tape may be installed around the rim of the container to help limit air flow and ensure a stable helium-enriched environment around the sample collection point.
f. Set up an inert gas tank and regulator to add the gas to the enclosure.
g. Connect the tubing from the inert gas tank to the container by inserting the tubing through the hole in the lower end of the container.
h. Introduce inert gas into the containment system and record concentration in the shroud. Open the ball valve and purge one tubing volume and begin measuring inert gas concentrations until three purge volumes have been removed. If the tracer concentration detected in the sample tubing is less than or equal to 10 percent (unless a different project-specific value applies) of the concentration of the inert gas in the shroud, the seal is considered competent. If the inert gas is detected in the sample tubing above 10 percent relative to the concentration in the shroud, then the seal around the sampling point is not competent and additional bentonite must be installed prior to sampling. Repeat the leak check procedure until less than or equal to 10 percent of the inert gas is detected. Record the final inert gas concentration in the field book or on a field form. Purging three to five purge volumes while collecting inert gas readings prior to sample collection is ideal.
i. Use the ball valve on the T-connector to redirect flow from the inert gas detector to the sampling canister, or if a T-connector is not used, remove the sample tubing from the inert gas detector and immediately connect the sample collection apparatus. Cover the end of the tubing when changing the tubing over so ambient air does not enter the sample tubing.
j. Complete shut-in leak test described in Section D.3 above if the sample collection train was not enclosed in the tracer containment apparatus (e.g., inverted container) during quantitative tracer testing. Otherwise, proceed with sample collection as described in Section 2.2.5 of the SOP.

Title: **Indoor and Ambient Air Sampling**		Procedure Number: **ECR 024**	
		Revision Number: **0**	
		Effective Date: **February 2019**	
Authorization Signatures			
Technical Reviewer Stacy Metz	Date 2/7/19	ECR Practice Quality Coordinator Elizabeth Denly	Date 2/7/19

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to provide guidance to TRC personnel in the logistics, collection techniques, and documentation requirements for collecting representative indoor air and ambient air samples for volatile organic compounds (VOCs) using sampling canisters. These are standard (*i.e.,* typically applicable) operating procedures that may be changed, as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In addition, other local, state or federal regulatory requirements may be above and beyond the scope of this SOP and should be followed, if applicable. In all instances, the actual procedures used should be thoroughly documented and described in the field notes. The project-specific work plan (or equivalent) should be consulted to verify sampling requirements and details as specified by the contractual agreement with the client.

There are other methods that can be used for the collection of indoor and ambient air samples for VOCs and other parameters including Tedlar® bags and sorbent tubes. In addition, some canisters can be used for the collection of analytical parameters other than VOCs (*e.g.,* fixed gases, non-methane organic compounds, methane, etc.). However, this SOP focuses only on the use of sampling canisters for VOCs.

1.2 Summary of Method

The objective of indoor and ambient air sampling is to obtain a representative sample of air for laboratory analysis of chemical constituents of interest at a given site. This objective requires that the sample be of sufficient quantity (*i.e.,* volume) and quality for analysis by the selected analytical method. Indoor and ambient air samples are typically collected with sampling canisters for VOC analysis. Sampling canisters under vacuum are commonly fitted with flow controllers to restrict the air intake to a pre-determined rate.

This sample collection method involves the use of a flow controller or a sampler containing a flow controller to slowly meter the flow of air entering a canister. With this method, a sample is collected over a longer period of time than with a grab sample. If a constant flow rate is maintained, the resulting sample will have a constituent content that is the average of the constituent concentrations during the sampling interval.

1.3 Equipment

The following list of equipment may be utilized when conducting indoor or ambient air sampling for chemical constituents. Project-specific conditions or requirements may warrant the use of additional equipment and/or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), such as nitrile gloves and safety glasses, as set forth in a site-specific health and safety plan (HASP) or job safety analysis (JSA).
- Barometric Pressure Meter – Extech® Instrument, or equivalent (optional – see site-specific work plan).

- Clean 5-gallon buckets, tripod, or box – For elevating sampling equipment to the breathing zone.

- Portable organic vapor analyzer equipped with a photoionization detector (PID) and/or flame ionization detector (FID) (optional).

- Air Flow Velocity Meter – TSI® 964 Straight Air Velocity Probe for use with Q-Trak™ Indoor Air Quality Monitor Model 7575, or equivalent (optional).

- Pre-cleaned, evacuated, passivated stainless-steel canister (hereafter - sampling canister), at least one extra for every 20 samples recommended in case of leakage.

- Flow controller(s)/regulators are generally pre-calibrated by the laboratory to regulate flow for sample collection times of 1-hour, 3-hours, 8-hours, 12-hours, or 24-hours as requested. Sample collection time is typically set based on project objectives. For example, 24 hours to evaluate residential exposure versus 8 hours or 12 hours to evaluate non-residential exposure.

- Vacuum gauge to verify readings on canister's flow controller (should be supplied by the laboratory and connected to the flow controller/regulator).

- Stainless-steel, Teflon®, or nylon tubing (sometimes used to extend equipment into the breathing zone).

- Moisture filter (may be needed for ambient air sampling).

1.4 Definitions

Individual Certification A laboratory will clean several sampling canisters at once. Each canister from the batch is certified as clean.

Batch Certification A laboratory will clean several sampling canisters at once. One randomly selected canister from that group of canisters, *i.e.,* the batch, is used to certify that all of the canisters in that batch are clean.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. TRC personnel will use appropriate PPE. The Project Manager, Office Safety Coordinator (OSC), TRC ECR Safety Manager, or TRC National Safety Director can address questions or safety concerns. Project-specific safety considerations should be documented in the project-specific work plan (or equivalent).

1.6 Cautions and Potential Problems

- When collecting air samples having high constituent concentrations, try to stay upwind of vapors during sample collection to minimize exposure. Respiratory protection may be required in certain instances depending upon site conditions and concentrations encountered.

- Sampling canisters should not be used for the collection of outdoor ambient air samples in moderate to heavy rain, as the moisture may compromise the sample. If the sampling event must occur when rain is forecasted, then the laboratory should be consulted to evaluate the limitations of the equipment.

- Factors, such as atmospheric conditions or dust/dirt blockage, can affect the actual flow rate through the calibrated flow controllers. Conditions should be properly noted in the field notes.

- For time-weighted sampling periods, it is important that the sample canister vacuum not equilibrate with atmospheric pressure in order to demonstrate that the sampling apparatus was functioning properly and collecting a representative sample over the prescribed time period.

- It is also important that the vacuum on the sample canisters does not exceed a maximum vacuum at the conclusion of the sampling period. Typically, if the vacuum is greater than 10 inches Hg, the laboratory will need to pressurize the samples with clean air, resulting in a slight dilution factor and, thus, elevated reporting limits.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that may entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers and 8-hour annual HAZWOPER refresher training.
- OSHA 10-hour Construction Industry Outreach Training.
- Site-specific safety training.

2.0 PROCEDURES

2.1 Pre-sampling Activities

1. Review regulatory requirements to ensure program requirements meet local regulations, which may specify collection of a concurrent ambient outdoor air sample, certain quality control (QC) samples, and/or specific ancillary measurements.

2. Based on project needs, a prescreening survey with a portable organic vapor analyzer may be helpful in determining preferential pathways or areas with high concentrations of VOCs.

3. Conduct a building condition assessment including a visual survey of basements, crawl spaces, slab-on-grade configurations and conditions; determine if sumps, wells, or cisterns are associated with the structure; evaluate the condition of floors and walls; and describe the HVAC system and operating status/conditions.

4. Verify if a pre-sampling survey of the building is required and if products containing compounds on the analyte list can be removed from the building in advance of sampling. Complete an Indoor Air Sampling Inventory using a form specified by the applicable regulatory agency (where applicable).

5. Verify if batch certification of sampling canisters is sufficient or if one or more sampling canisters require individual certification. This will be dependent on project objectives.

6. The flow controller sampling period should be specified in the sampling plan or project-specifc work plan and confirmed with the Project Manager. Sample collection time is typically set based on project objectives. For example, 24 hours to evaluate residential exposure versus 8 hours or 12 hours to evaluate non-residential exposure.

7. Perform site reconnaissance to plan potential ambient outdoor air sampling locations. If collecting an ambient outdoor air sample for background purposes, place the sampling apparatus upwind of the study area, and set the intake of the flow controller in the breathing zone (3 to 5 feet above the ground). Safety, access, and security variables should be considered.

8. Typically, the intake of the sampling apparatus should be within the breathing zone (3 to 5 feet above the floor) so the sampling apparatus should be placed on an elevated surface. If a sufficient elevated surface is not present in the sampling area, one should be mobilized to the site (*e.g.,* buckets, tripod or cardboard boxes without VOC-containing tape). NOTE: Review regulatory requirements for the proper height of the samplers; New Jersey guidance recommends the intake be biased near cracks or openings and not the breathing zone when sampling in basements.

   CAUTION: Be sure that the elevated surface is secure and stable, especially in active work areas. Sampling canisters are fragile and are likely to break if knocked to the ground, costing time (especially if damage occurs near the end of the sampling period) and money (sampling canisters cost thousands of dollars).

9. Verify the required sampling volume, minimum/maximum flow rates, minimum/maximum sampling duration, and the number and location of samples needed. These variables will be dependent upon project objectives, sampling method limitations, and required reporting limits. Consult with the Project Manager or the project-specific work plan.

10. Determine the appropriate sampling canister size with the selected analytical laboratory and ensure the laboratory will have enough volume to perform reanalyses and dilutions, if required. Note that smaller volume canisters limit the volume of sample available to laboratories. However, large sampling canisters can be expensive to ship and difficult to manage and transport in the field, particularly for large scale projects.

11. Field Measurement Equipment: If ancillary measurements are required, the associated equipment must be calibrated appropriately. Check with the Project Manager to establish whether ancillary measurements are required.

    a. Temperature and humidity: If erratic measurements are observed, consult the manufacturer for calibration requirements.

b. Barometric pressure: If erratic measurements are observed, consult the manufacturer for calibration requirements.

c. Air flow velocity: Equipment should be pre-calibrated by the rental company. If erratic measurements are observed, consult the rental company or manufacturer for calibration requirements. Records of calibrations should be provided by the rental company and maintained in the project file.

NOTE: Weather Underground (www.wunderground.com) or other online weather service providers can also be used as a potential resource for atmospheric condition measurements.

2.2 Sampling Procedures

1. The connection between the air-flow controller and the sampling canister is likely to vary between laboratories. Be sure to follow the laboratory-provided directions when connecting the flow controller to the sampling canister. Quick-connect fittings are typically simple and trouble-free, whereas compression type fittings are more common, but may also be more troublesome due to preexisting imperceptible damage, *i.e.,* minor abrasions caused by dust/dirt and/or deformation caused by overtightening. Common suggestions for connecting the flow controller to the sampling canister using compression-type fittings are as follows:

   (a) Confirm the valve is closed (knob should already be tightened clockwise) before unthreading the stainless-steel plug from the top of the canister.

   (b) Check to see that the O-ring is still in place prior to making the connection. Ensure extra O-rings and ferrules are shipped with the flow controller in case they are damaged or missing.

   (c) If present, remove the plastic cap from the flow controller outlet (male threads) before attempting to connect to the inlet on the sampling canister.

   (d) Do not over-tighten compression fittings.

2. Set the sampling apparatus intake in the breathing zone (3 to 5 feet above the floor). Do not set canister on a structure or materials that may off-gas constituents of potential concern. NOTE: Review regulatory requirements for the proper height of the samplers; New Jersey guidance recommends the intake be biased near cracks or openings and not the breathing zone when sampling in basements. Record the sample collection location and height.

3. Open the sampling canister valve to begin sampling. Record the start time, flow controller rate, initial vacuum, and sampling canister size. Also record the flow controller and sampling canister identification numbers.

4. Observe the sampling apparatus for 5 to 10 minutes to verify that the vacuum is dropping at a reasonable rate based on the target flow rate. If access is available, check the vacuum gauges at regular intervals over the sampling duration to ensure the vacuum is dropping appropriately.

5. To the extent feasible, ensure that the sampling apparatus remains undisturbed during prolonged sampling. At residential properties, ask occupants to not disturb the sampling apparatus and to avoid using chemicals in the area of the sampling apparatus that could affect sample results. In industrial settings, periodically check the sampling apparatus to ensure it remains undisturbed.

6. Close the sampling canister valve after the designated time period has been completed, and replace the cap. Record the final vacuum and the time sampling was completed prior to disconnecting the flow controller. It is typically recommended that the canister vacuum not be allowed to drop to zero and a residual vacuum should remain in the canister. The final canister vacuum should typically be between 5- and 8-inches Hg. This vacuum, when verified by the analytical laboratory upon receipt, provides evidence that the sample canister did not leak during the return shipment.

7. Complete the chain-of-custody (COC) form. See Attachment B for an example COC form.

8. Transport the samples to the analytical laboratory for processing. Note that sampling canisters do not need to be stored on ice. Consequently, overnight shipment is not required to maintain sample integrity. Using 2-day shipping or even ground transport can substantially reduce project costs.

2.3 Ancillary Measurements

Field measurements may be required in association with indoor air sampling. Continuous temperature, barometric pressure, and/or humidity measurements may be required at each sampling location using appropriate sensors and logging devices. Air flow velocity measurements may be required for supply and exhaust (or return) air vents in each room.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

The following list is a summary of quality assurance/quality control (QA/QC) procedures that can be used to help ensure the accuracy and precision of the sampling method. The process and requirements for the collection of specific field QC samples will be specified in the project-specific planning documents.

3.1 Field Duplicates

Field duplicates are collocated samples. Collocated samples are two samples collected next to each other in the same position at the same location, at the same time, and for the same amount of time. Field duplicates are used to assess the precision of the sampling and analytical methodologies. Field duplicates, when required, are typically collected at a frequency of one per day of sampling or one per 20 samples.

3.2 Media Certification Checks

Media for all analyses are typically certified as clean from the laboratories. The certifications are performed as batch checks, and results are stored in the project files.

Sampling canisters that are individually certified should have the certification attached to the final laboratory report.

4.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Information relevant to the indoor sampling location should be recorded during each sampling period (*e.g.,* number of interior and exterior doors and windows, number of windows open and closed, type of ventilation system and its status during each sampling period, room temperature, and any other conditions that might affect concentrations in air over time, such as site operations, material storage, or motorized vehicle storage and/or operation).

If ancillary measurement equipment is used, the applicable calibration information (*i.e.,* date, times, equipment make/model/serial number, and calibration results) should also be recorded.

Record the following information:

- Sampling location;
- Sampling canister size;
- Pre-set flow rate on flow controller;
- Height of sampling canister;
- Laboratory canister ID;
- Laboratory flow controller ID;
- Atmospheric conditions (*e.g.,* dusty, dirty);
- Sampling start time and vacuum (inches of Hg);
- Sampling end time and vacuum (inches of Hg); and
- Indoor and outdoor barometric pressure (optional).

Example Field Sampling Data Sheets and an example COC form are presented in Attachments A and B, respectively.

5.0 REFERENCES

American Society for Testing and Materials (ASTM). November 2014. ASTM D1945-14. *Standard Test Method for Analysis of Natural Gas by Gas Chromatography*.

United States Environmental Protection Agency (USEPA). January 1999. Compendium Method TO-10A: *Determination of Pesticides and Polychlorinated Biphenyls in Ambient Air Using Low Volume Polyurethane Foam (PUF) Sampling Followed by Gas Chromatographic/Multi-Detector Detection (GC/MD)*. EPA/625/R-96/010b.

USEPA. August 2017. Method 25C. *Determination of Nonmethane Organic Compounds (NMOC) in Landfill Gases*.

6.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	FEBRUARY 2019	Not applicable.

Attachment A

Example Field Sampling Data Sheets

PAGE ______ OF ______

AIR / VAPOR SAMPLE LOG

PROJECT NAME:	PREPARED	CHECKED
PROJECT NUMBER:	BY: DATE:	BY: DATE:

SAMPLE INFORMATION			
SAMPLE TYPE:	☐ COMPOSITE ☐ GRAB	**SAMPLE ID:**	
SAMPLE MEDIA	☐ INDOOR AIR ☐ SOIL VAPOR ☐ SYSTEM PERFORMANCE ☐ OTHER	LOCATION:	LOCATION COORDINATES: N: E:
SAMPLE DURATION:		SAMPLE HEIGHT / (DEPTH):	
SAMPLE CONTAINER TYPE:	☐ SUMMA CANISTER ☐ TEDLAR BAG	☐ OTHER:	
FLOW VALVE ID / SERIAL NUMBER:		CANISTER SERIAL NUMBER:	

READING	TIME	VACUUM (INCHES - Hg / PSIG)	DATE	INITIALS	COMMENTS
INITIAL VACUUM CHECK					
INITIAL FIELD VACUUM					
FINAL FIELD VACUUM					

SAMPLE START TIME:	**SAMPLE STOP TIME:**

NOTES AND OBSERVATIONS
MOTORIZED VEHICLE STORAGE:
MOTORIZED VEHICLE TRAFFIC:
OPERATIONS (e.g., painting, oil recovery):
CLEANERS / SOLVENTS IN USE:
MATERIAL STORAGE (e.g., paint, gasoline):
NOTICEABLE ODORS:
AUDIBLE OR NEARBY HVAC OPERATION:
OTHER:

ADDITIONAL COMMENTS:

SHIPPING METHOD:	DATE SHIPPED:	AIRBILL NUMBER:
COC NUMBER:	SIGNATURE:	DATE SIGNED:

REVISED 06/2011

AIR MONITORING DATA SHEET

CLIENT: ____________________

DATE: ____________________ INSTRUMENT SERIAL NO.: ____________________
TECHNICIAN: ____________________ INSTRUMENT MODEL NO.: ____________________

LOCATION ID	SAMPLING TIME		CANISTER DATA			BAROMETRIC PRESSURE (in. Hg)	AMBIENT AIR TEMP (°F)	BUILDING CLOSED? (i.e., windows/ doors closed) (YES/NO)
	START	FINISH	CAN NO.	INITIAL PRESSURE (in. Hg)	FINAL PRESSURE (in. Hg)			
INDOOR AIR MONITORING LOCATIONS								
AMBIENT AIR MONITORING LOCATIONS								

NOTE:

Attachment B

Example Chain-of-Custody Form

H&P Mobile Geochemistry Inc.

2470 Impala Drive, Carlsbad, CA 92010
& Field Office - Signal Hill, CA
W handpmg.com E info@handpmg.com
P 760.804.9678 F 760.804.9159

VAPOR / AIR Chain of Custody

DATE:________
Page ____of____

Lab Client and Project Information	
Lab Client/Consultant:	Project Name / #:
Lab Client Project Manager:	Project Location:
Lab Client Address:	Report E-Mail(s):
Lab Client City, State, Zip:	
Phone Number:	

Sample Receipt (Lab Use Only)	
Date Rec'd:	Control #:
H&P Project #:	
Lab Work Order #:	
Sample Intact: ☐ Yes ☐ No ☐ See Notes Below	
Receipt Gauge ID:	Temp:
Outside Lab:	
Receipt Notes/Tracking #:	
Lab PM Initials:	

Reporting Requirements	Turnaround Time		Sampler Information
☐ Standard Report ☐ Level III ☐ Level IV	☐ 5-7 day Stnd	☐ 24-Hr Rush	Sampler(s):
☐ Excel EDD ☐ Other EDD:__________	☐ 3-day Rush	☐ Mobile Lab	Signature:
☐ CA Geotracker Global ID:__________	☐ 48-Hr Rush	☐ Other:____	Date:

Additional Instructions to Laboratory:

** Preferred VOC units (please choose one):*
☐ µg/L ☐ µg/m³ ☐ ppbv ☐ ppmv

SAMPLE NAME	FIELD POINT NAME (if applicable)	DATE mm/dd/yy	TIME 24hr clock	SAMPLE TYPE	CONTAINER SIZE & TYPE	CONTAINER ID (###)	Lab use only: Receipt Vac	VOCs Standard Full List ☐ 8260SV ☐ TO-15	VOCs Short List / Project List ☐ 8260SV ☐ TO-15	Oxygenates ☐ 8260SV ☐ TO-15	Naphthalene ☐ 8260SV ☐ TO-15	TPHv as Gas ☐ 8260SVm ☐ TO-15m	Aromatic/Aliphatic Fractions ☐ 8260SVm ☐ TO-15m	Leak Check Compound ☐ DFA ☐ IPA ☐ He	Methane by EPA 8015m	Fixed Gases by ASTM D1945 ☐ CO2 ☐ O2 ☐ N2				

Approved/Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
Approved/Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
Approved/Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:

Standard Operating Procedure Installation and Extraction of the Vapor Pin®

Updated March 16, 2018

Scope:

This standard operating procedure describes the installation and extraction of the VAPOR PIN® for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the VAPOR PIN® for the collection of sub-slab soil-gas samples or pressure readings.

Equipment Needed:

- Assembled VAPOR PIN® [VAPOR PIN® and silicone sleeve(Figure 1)]; Because of sharp edges, gloves are recommended for sleeve installation;
- Hammer drill;
- 5/8-inch (16mm) diameter hammer bit (hole **must** be 5/8-inch (16mm) diameter to ensure seal. It is recommended that you use the drill guide). (Hilti™ TE-YX 5/8" x 22" (400 mm) #00206514 or equivalent);
- 1½-inch (38mm) diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch (19mm) diameter bottle brush;
- Wet/Dry vacuum with HEPA filter (optional);
- VAPOR PIN® installation/extraction tool;
- Dead blow hammer;
- VAPOR PIN® flush mount cover, if desired;
- VAPOR PIN® drilling guide, if desired;
- VAPOR PIN® protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel for repairing the hole following the extraction of the VAPOR PIN®.

Figure 1. Assembled VAPOR PIN®

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch (38mm) diameter hole at least 1¾-inches (45mm) into the slab. Use of a VAPOR PIN® drilling guide is recommended.

4) Drill a 5/8-inch (16mm) diameter hole through the slab and approximately 1-inch (25mm) into the underlying soil to form a void. Hole **must** be 5/8-inch (16mm) in diameter to ensure seal. It is recommended that you use the drill guide.

5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

6) Place the lower end of VAPOR PIN® assembly into the drilled hole. Place the small hole located in the handle of the installation/extraction tool over the vapor pin to protect the barb fitting, and tap the vapor pin into place using a dead blow hammer (Figure 2). Make sure the installation/extraction tool is aligned parallel to the vapor pin to avoid damaging the barb fitting.

Figure 2. Installing the VAPOR PIN®

During installation, the silicone sleeve will form a slight bulge between the slab and the VAPOR PIN® shoulder. Place the protective cap on VAPOR PIN® to prevent vapor loss prior to sampling (Figure 3).

Figure 3. Installed VAPOR PIN®

7) For flush mount installations, cover the vapor pin with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover (Figure 4).

Figure 4. Secure Cover Installed

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the VAPOR PIN®. This connection can be made using a short piece of Tygon™ tubing to join the VAPOR PIN® with the

Nylaflow tubing (Figure 5). Put the Nylaflow tubing as close to the VAPOR PIN® as possible to minimize contact between soil gas and Tygon™ tubing.

Figure 5. VAPOR PIN® sample connection

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the VAPOR PIN® via Mechanical Means (Figure 6). For flush-mount installations, distilled water can be poured directly into the 1 1/2 inch (38mm) hole.

Figure 6. Water dam used for leak detection

11) Collect sub-slab soil gas sample or pressure reading. When finished, replace the protective cap and flush mount cover until the next event. If the sampling is complete, extract the VAPOR PIN®.

Extraction Procedure:

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the VAPOR PIN® (Figure 7). Turn the tool clockwise continuously, don't stop turning, the VAPOR PIN® will feed into the bottom of the installation/extraction tool and will extract from the hole like a wine cork, DO NOT PULL.

2) Fill the void with hydraulic cement and smooth with a trowel or putty knife.

Figure 7. Removing the VAPOR PIN®

- Prior to reuse, remove the silicone sleeve and protective cap and discard. Decontaminate the VAPOR PIN® in a hot water and Alconox® wash, then heat in an oven to a temperature of 265° F (130° C) for 15 to 30 minutes. For both steps, **STAINLESS – ½ hour, BRASS 8 minutes**

Other Applicable Procedures

Title:	Procedure Number:
Test Pit Investigations	**RMD 012**
	Revision Number: **0**
	Effective Date: **November 2014**

Authorization Signatures	
	Elizabeth Denly
Technical Reviewer — Date James Peronto — 11/17/2014	Remediation Practice Quality Coordinator — Date Elizabeth Denly — 11/17/2014

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Page No.

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for completing and logging test pits during field investigations at hazardous and non-hazardous waste sites.

1.2 Summary of Method

The objective of a test pit investigation is to observe and document subsurface conditions in an area of interest to the project. This SOP presents typical test pit logging procedures; however, implementation may vary based upon project-specific needs.

Typically, heavy equipment (e.g., excavator or backhoe) is utilized to remove soil or material in designated cuts or layers, creating a rectangular surface area test pit. The test pit is usually a narrow excavation (relative to its width) made below ground surface. The total depth and width of the test pit vary based on project objectives. Personnel gather various data from the test pit without entering the excavation, unless appropriate engineering/safety controls are implemented. The test pit is then properly backfilled and closed. Closure may include replacement of excavated soils, installation of appropriately characterized backfill, compaction, and restoration of surface conditions (e.g., paving) based on site-specific conditions and work plan-specific requirements.

A test pit investigation is typically conducted for the following reasons:

- Documenting and observing subsurface conditions and lithology;
- Confirming depth to bedrock;
- Obtaining sidewall or excavation floor soil/material samples;
- Identifying the vertical and horizontal extent of soil contamination or non-native fill material below ground surface;
- Conducting percolation tests;
- Conducting soil density tests;
- Identifying preferential pathways below ground surface;
- Investigating historical structures (e.g., suspect or former underground storage tanks); and
- Investigating anomalous results of geophysical surveys completed at the surface.

1.3 Equipment

The following list of equipment includes the items that may be used by TRC personnel during the excavation of test pits. Subcontractor personnel typically provide and operate all excavation and other construction-related equipment. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Test pit sampling plan
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags
- Caution or danger flagging tape

- Measuring tape with weight (0.1-foot increments)
- Pocket penetrometer
- Applicable air monitoring equipment, such as photoionization detector (PID) or flame ionization detector (FID), as specified in the HASP
- Field book
- Test pit log sheets
- Camera
- Calculator
- Polyethylene sheeting (may be provided by contractor)
- Sample container labels
- Chain-of-custody (COC) forms (TRC or laboratory, as appropriate)
- See soil sampling supplies from RMD SOP 003, Soil Sampling
- See soil description supplies from RMD SOP 005, Visual-Manual Procedure for Soil Description and Identification
- See equipment decontamination supplies from RMD SOP 010, Equipment Decontamination
- Indelible marking pens or markers
- Organic absorbent (e.g., Slikwik®, ground corn cob, sawdust)
- Sample coolers
- Ice (for sample storage/preservation)
- Zip-loc® plastic bags (for ice and COC forms)
- Survey equipment and/or global positioning system (GPS) and/or other means of establishing test pit and/or sample locations

1.4 Definitions

Spoils Pile	(a.k.a. stockpile): Soil or other material removed from an excavation and temporarily stored on site during an investigation.
Swing Radius	The area that can be reached as a piece of earth-moving equipment (e.g., excavator) swings its extension arm and bucket around 360 degrees as the base remains stationary.
Test Pit	A typically shallow excavation performed to observe and document subsurface conditions in an area of interest.

1.5 Health & Safety Considerations

Any test pit can present physical dangers, such as difficult entry and exit; slip, trip, and fall hazards; and the possibility of cave-ins, which could trap and suffocate workers. At contaminated sites, chemical hazards may also cause low-lying areas, such as a test pit, to collect high-density gases and vapors.

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Specifically, test pits require additional safety precautions that are related to heavy equipment operation, excavation safety, and hazardous atmospheres. These safety precautions should be listed within the site-specific HASP and comply with Occupational Safety and Health Administration (OSHA) guidance on trenching and excavations (29 CFR Part 1926 Subpart P). TRC personnel must read and understand the site-specific HASP prior to implementing this SOP.

General Test Pit Safety Rules:

- Keep heavy equipment away from test pit edges.
- Identify other sources that might affect test pit stability.
- Keep excavated soil (spoils) and other materials at least 2 feet from test pit edges.
- Conduct a utility clearance before digging.
- Test for atmospheric hazards, such as low oxygen, hazardous fumes, and toxic gases when >4 feet deep.
- Inspect test pits at the start of each shift.
- Inspect test pits following a rainstorm or other water intrusion event.
- Do not work under suspended or raised loads and materials.
- Inspect test pits after any occurrence that could have changed conditions in the test pit.
- Ensure that personnel wear high-visibility or other suitable clothing when exposed to vehicular traffic.
- Maintain eye contact with the excavator operator so that they know where you are at all times. If you want to approach the excavator or test pit, signal the operator first and ensure the equipment is stopped before you approach.
- Watch for tell-tale signs of instability in the test pit (e.g., cracks, sloughing, inflow of water). Do not approach the crest of the pit if instability is perceived. Also note that soil can and will fail beneath asphalt, so take extra care when excavating through paved surfaces.
- Mark the location of the test pit with orange cones or flagging to alert others of the presence of the test pit.
- Backfill the test pit as soon as possible once the investigation is done. Do not allow the test pit to remain open.

Refer to RMD SOP 003, Soil Sampling for details on health and safety issues related to soil sampling.

1.6 Cautions and Potential Problems

The following is a list of problems that may arise during a test pit investigation:

- Cave-in (Sidewall Collapse)

The primary hazard during test pit completion is injury from a cave-in. Evaluation of soil physical properties is important and should be conducted as much as practical before test-pitting commences (e.g., through analysis of available soil maps or previously installed boreholes) and as much as practical while the test pit advances in depth to determine appropriate sloping, benching, and shoring in order to mitigate potential sidewall cave-in. Field personnel can fall into the test pit by standing too close to the edge of the excavation during the cave-in. Essential personnel should stand a minimum of 2 feet from the edge of the test pit and should not stand between the spoils pile and the edge of the test pit.

At no time will TRC personnel enter a test pit that is ≥4 feet deep to gather data, unless appropriate engineering/safety controls are implemented. Test pits that are ≥4 feet deep require provision of safe access and egress, such as ladders, steps, or ramps, to all workers. Such devices must be located within 25 feet of all workers. Test pits ≥5 feet deep require the use of a protective system, unless the excavation is made entirely in stable rock. **At no time will TRC personnel enter an unprotected test pit that is ≥5 feet deep or a test pit in which water has accumulated.**

- Communication

Due to the excessive noise emitted from heavy machinery (e.g., backhoe/excavator, water truck, etc.), it is advised that the use of hand signals be established between TRC personnel and the equipment operator/subcontractors before conducting any equipment movement or operation. Furthermore, TRC personnel need to maintain eye contact with the equipment operator(s) and awareness of equipment movement, and remain outside of the equipment swing radius and/or outrigger radius at all times during operation. At no time will TRC personnel be allowed to work under raised loads or equipment (e.g., buckets, booms, outriggers, cables, shackles, steel plates, etc.).

Additionally, personnel should wear Department of Transportation (DOT)-approved safety vests or other suitable garments with reflective/high-visibility materials. When test-pitting activities need to take place adjacent to or within public roadways, it may be necessary to arrange for a designated, trained flag person with signs and barricades.

- Airborne contaminants and particulates

During test pit investigations, hazardous soil vapor and/or particulate matter may become airborne. Appropriate dust and vapor suppression controls shall be implemented during excavation and material placement. Consult the site-specific HASP and local regulatory agency requirements for air monitoring and respiratory requirements. Consult the site-specific work plan and/or Project Manager to determine whether any in-field notifications to nearby property owners may be required.

- Collection of soil samples

Due to safety precautions, direct collection of soil samples from the sidewalls and floor of the test pit may not be possible. Therefore, soil sampling activities during the test pit investigation often may employ unique soil sample collection methodologies. Typically, this requires the use of the backhoe or excavator bucket for retrieval of the samples from the desired location. Care should be exercised during sample collection from the equipment bucket due to the presence of heavy machinery. It is advised that TRC personnel ensure the sample material does not become disturbed while the bucket is being lifted to the ground surface from the test pit prior to sample collection. Avoid collecting a sample that was in direct contact with the backhoe bucket or other machinery. Further discussion of these methodologies is presented below in Section 2.0.

- Potentially hazardous buried objects/materials

Watch carefully for buried objects/materials, especially materials that may pose a safety hazard. If buried containers potentially containing liquids (e.g., drums, carboys, or tanks) are encountered, cease excavation and notify the Project Manager.

- Utilities

The first step in any site excavation/test-pitting program is to notify the public utility locating service for the respective city or state. Advance notifications must be given in accordance with public locating service requirements (e.g., 72 hours in advance). Prior to notification, areas requested to be surveyed and marked by the utility locating service must be clearly identified/marked in the field by TRC in accordance with any pre mark-out requirements (e.g., correct spray paint color [white] and appropriate words [e.g., Dig Safe, Call Before You Dig (CBYD)]). The call to the utility locating service will set in motion the mark-out process, whereby documented underground utilities are marked, if any exist. For test pit programs on private properties in urban settings or locations having prior development, third-party utility locating services must be hired to locate and mark buried utilities not located in public right-of-ways that are marked out by public utility locating services.

Nonetheless, as noted below, caution should be exercised during any excavation in case utilities at the location were not identified and marked. Notify the utility locating services early in the design phase to aid in siting test pits to avoid known utilities in advance and to help minimize potential in-field adjustments. Note that another follow-up utility locating service notification may then be required prior to test pit excavation activities depending upon the advance notification requirements (e.g., no more than 10 days in advance). Take note of overhead utilities and work clear of them to avoid electric shock, injury, and property damage. Overhead power lines are a major concern and must be avoided or de-energized. Even without direct contact, electricity can arc from the power lines to another object.

Before beginning the test pit excavation, walk the site and identify potential locations for investigation and utilities. Do not just rely on the utility locating service and their associated mark-out. Actively look for evidence of underground services (e.g., service boxes, plugs, exposed pipes, trenches, etc.), locate the test pits accordingly, and remain cognizant of utilities during the performance of the work. If there is evidence of a potential buried utility with no visible mark-out, the location should be avoided until surveyed by a third-party utility locating service or the suspect buried utility is confirmed absent or deactivated by other means.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- OSHA 8-hour Health and Safety Training for HAZWOPER supervisors
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

It is strongly advised that TRC coordinate with the test pit contractor prior to on-site mobilization to ensure the chosen equipment will meet the test pit depth requirements.

The following procedures should be used during the implementation of test pit investigation activities. Always refer to the site-specific work plan and/or scope of work for any site-specific sampling procedures. Procedures may vary depending on the activities being performed, type of equipment used, excavation requirements, sampling strategy and contaminants present at the site. Site-specific conditions may warrant the use of air monitoring, PPE and access restrictions; these will be defined in the site-specific HASP.

2.1 Preparation

The following items should be considered during preparation of test pit activity.

- The scope of the investigation, objectives, potential contaminants, spoils pile segregation, soil management plan, and HASP (as applicable) should be reviewed with all subcontractor personnel prior to initiation of the test pit investigation.
- All intended hand signals to be used during the excavation should be reviewed and understood between the TRC personnel directing the operation and the equipment operator(s).
- Prior to penetrating the ground surface, TRC personnel shall ensure that proper utility clearances have been performed by the appropriate responsible party(s). No work shall commence if the proper utility clearance has not been authorized.
- Typically, one individual will be designated to direct the operator; make observations and complete a written field log; conduct work area, excavation or continuous air monitoring; and be responsible for record-keeping, photography, sample collection, storage and documentation. Alternately, two personnel can perform these tasks depending on the objective, complexity and duration of the test pit investigation.
- It is a good practice to also photo document the site conditions prior to excavation activities.
- All safety monitoring equipment (e.g., PID, dust meter) will be operational and pre-calibrated prior to the first test pit. Refer to the equipment manufacturer documentation for proper calibration procedures.
- Specific provisions for segregation and stockpiling of waste materials that might be encountered/excavated should also be taken into account in the site-specific work plan (see Section 3.0 below).

2.2 Test Pit Investigation

1. The location and estimated total depth(s) of the test pit(s) should be identified in the site-specific work plan.

2. If subsurface utility line locations were identified at or nearby the location prior to test-pitting, then TRC personnel should inform the excavation equipment operator/subcontractor of the locations and instruct them to excavate with extreme caution. If there is a suspect or known buried utility at the location where the test pit is to be completed and the test pit location cannot be moved, the utility should first be deactivated, if possible. In addition,

excavation using an excavator bucket at the location should be minimized or avoided until the utility is uncovered and located by hand digging with a shovel. In most instances, it may be prudent to have a utility representative on site to help identify underground utilities at or in close proximity to planned test pit locations, especially if assistance is required to more accurately locate and/or deactivate the utility.

3. If required, erosion controls (e.g., silt socks, silt fencing, hay bales) will be installed around the test pit to prevent surface runoff from contaminating adjacent surface soils. Initiate the excavation in appropriate lifts as directed in the site-specific work plan. Record observations as the test pit is advanced. Test pits are typically advanced in a linear fashion and are rectangular in shape.

   - Excavated soil/material should be placed an appropriate distance away from the edge of the test pit to minimize potential collapse of a sidewall; for safety purposes excavated soil/material should never be placed closer than 2 feet from the edge of the test pit.
   - If contamination is anticipated or encountered, TRC personnel should have the contractor position polyethylene sheeting (at least 6 mil) next to the test pit on which to place excavated soils to prevent cross-contamination of adjacent surface soils, pavement or otherwise covered surface. For safety reasons, TRC personnel observing spoil piles should not stand between the stockpiled soil/material and the test pit.
   - Excavation activities and observations should be recorded in the field book or on a Test Pit Log, which is provided in Attachment A.

4. The rationale for soil sample collection locations and methods within the test pit, if any, should be pre-determined in the site-specific work plan. In many cases, soil/material will be brought to the surface in the equipment bucket for soil/material sampling. When this is performed, the TRC field personnel typically direct the equipment operator to the desired sidewall or excavation floor location to collect the sample using the equipment bucket. Once the equipment bucket is lifted to the ground surface, TRC personnel shall instruct the operator to place the bucket on the ground surface and turn off the equipment motor.

   - It may be advisable to remove the upper surface (approximately 3 to 6 inches or more) of recovered materials to obtain undisturbed material from the equipment bucket (as opposed to the materials from the sidewall that were exposed to the atmosphere while the test pit was being advanced).
   - It is further advised that TRC personnel ensure the sample material does not become disturbed while the bucket is being lifted to the ground surface from the test pit prior to sample collection.
   - Avoid collecting a sample that was in direct contact with the backhoe bucket or other machinery.
   - Soil samples collected for volatile organic compound (VOC) analysis should be collected prior to completing a stratigraphic description in order to minimize the time the test pit sidewall or floor is exposed to the atmosphere and volatilization. Soil samples for other chemical analyses should be collected as soon as possible upon exhumation in order to minimize the time soil samples are exposed to the atmosphere.
   - See RMD SOP 003, Soil Sampling for specific soil sampling techniques.

5. Typical observations and sample collection information documented in the field is presented in Section 5.0. Such information is typically documented in a Test Pit Log or the field book. Example Test Pit Logs are provided in Attachment A.

2.3 Closure of the Test Pit

1. Backfill and return the excavated area to match the original grade. TRC personnel should instruct the operator/subcontractor to backfill the excavated soil/material at approximately the same depth within the test pit that they were removed. Instruct the operator/subcontractor to compact the backfilled soil in lifts and to not leave surface depressions, holes, debris or other trip hazards at completion. Refer to the site-specific work plan, if applicable, for potential alternate closure requirements (e.g., compaction requirements, flowable fill) and whether excavated spoils observed to have signs of potential contamination (e.g., staining, odors, PID readings) should not be used for backfill.

2. Stake, label, flag and/or collect GPS coordinates or distance measurements to nearby physical reference points of the test pit center and pertinent features for future reference, reporting and/or surveying.

3. If segregation of contaminated soil and/or wastes has occurred, the disposition of these materials should be in accordance with the site-specific work plan. This will result in a deficit of fill material. Fill material utilized to replace this deficit must be in accordance with the site-specific work plan.

4. As specified in the site-specific work plan, return the surface conditions to pre-excavation conditions (e.g., loaming, seeding, mulching, paving) if required.

5. As specified in the site-specific work plan, erosion and sedimentation structures utilized must remain in place until the surface area has been stabilized (e.g., seed germination and plant growth to maturity, pavement replaced).

6. Documentation of site conditions upon demobilization from the site should be noted in the field book. High visibility fencing, barricades, and/or caution tape are mandatory for any excavation left unattended or open overnight. Photographs of the area are also recommended prior to field staff departure.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum or roll-off bin, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following samples: equipment blank, trip blank, field duplicate, and matrix spike/matrix spike duplicates (MS/MSDs). Refer to RMD SOP 003, Soil Sampling for quality assurance (QA)/QC procedures associated with soil sample collection.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the general sample collection information, such as location, identification, and date/time in the field book or on a Test Pit Log (See Attachment A for examples). Unless prescribed in the site-specific work plan or if different from the site-specific work plan, typical field documentation recorded on a Test Pit Log or in the field book includes the following information:

- Name of TRC and subcontractor personnel;
- Weather during test pit activity;
- Field screening results of soil and ambient conditions (e.g., VOCs, dust) in accordance with the site-specific work plan and HASP, as applicable;
- Visual signs of contamination, staining, petroleum or other odors, buried containers, or potential migration pathways;
- The depth and lateral position in the test pit of any subsurface samples collected (laboratory or geotechnical);
- GPS coordinates (X and Y) of the test pit location and coordinate system, if known,
- Ground surface or top of pit elevation of test pit; if known;
- Type of equipment used for excavation of test pit;
- The soil lithology - the depth to observed soil layers and the soil composition per RMD SOP 005, Visual-Manual Procedure for Soil Description and Identification;
- The depth to the groundwater table, if encountered;
- The presence of any immiscible (floating) layers or sheens in groundwater;
- Any aqueous samples that were collected and how aqueous samples were collected;
- Sample identification number(s);
- Field duplicate location;
- Sample location (description or sketch of the sample point);
- Sample depth interval(s);
- The dimensions of the test pit at completion;
- Distance measurements of test pit location to nearby physical reference points; and
- Photographs of the test pit sidewalls and bottom and any observed features of interest should be taken and recorded in the field book or on a Test Pit Log. Be certain to note the date, time, orientation of the photo and the direction that the photographer was facing (e.g., Photo #1 taken facing North). Be mindful of light conditions, such that inner test pit characteristics are not hidden or poorly visible in the final photographs.

Affix a properly completed label to each sample container.

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the site-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

RMD SOP 003, *Soil Sampling,* Revision 0, September 2013.

RMD SOP 005, *Visual-Manual Procedure for Soil Description and Identification,* Revision 0, September 2013.

RMD SOP 010, *Equipment Decontamination,* Revision 0, April 2014.

US Department of Labor, Occupational Safety and Health Administration, 29 CFR Part 1926.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	NOVEMBER 2014	NOT APPLICABLE

3) Replacement parts and supplies are available online.

Vapor Pin Enterprises, Inc.
• 7750 Corporate Blvd., Plain City, Ohio 43064 • (614) 504-6915 • www.vaporpin.com

Attachment A

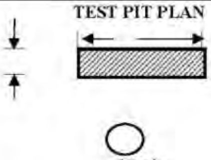
Example Test Pit Logs

Test Pit Log

TRC Test Pit Log	**Project Name/Number:**	**Test Pit Number:** Sheet___ of ___
	Location:	**Date/Time**
Equipment Used (e.g., reach/capacity):	**Contractor Personnel:**	**TRC Personnel:**
Total Depth:	**Contractor Used:**	**Top of Pit Elevation:**
Depth to Ground Water:	**Weather:**	

Depth	Sample Number	Stratigraphic Description	REMARKS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

TEST PIT PLAN



North

Vol = ____ cu. yd.

PROPORTIONS

☐ **BURMISTER USED**

Trace (TR)	0-10%
Little (LI)	10-20%
Some (SO)	20-35%
And	35-50%

☐ **USCS USED**

Trace (TR)	<5%
Few	5-10%
Little (LI)	15-25%
Some (SO)	30-45%
Mostly (MO)	>50%

GRAIN SIZE (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Comments: ______________________________

Rev: October 2014

LOG OF TEST PIT OR EXCAVATION

TEST PIT NUMBER: ____________________

PROJECT NAME: ______________________________ PROJECT NUMBER: ____________________

LOCATION: ______________________________ DATE: ____________________

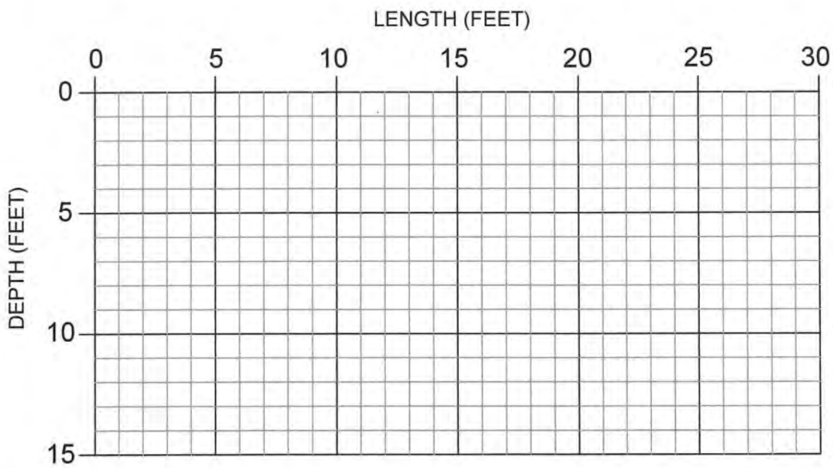
CONTRACTOR: ______________________________

METHOD: ______________________________ WIDTH: ____________________

LOGGED BY: ______________ CHECKED BY: ______________ PAGE: __________ OF __________

GRAPHIC REPRESENTATION OF EXCAVATION

(SECTION ALONG LENGTH OF TRENCH)



ORIENTATION:

____

TO

____

DESCRIPTION OF UNITS

Attachment B

SOP Fact Sheet

TEST PIT INVESTIGATIONS

Purpose and Objective

The objective of completing test pits is to observe and document subsurface conditions in an area of interest to the project.

Typically, heavy equipment (e.g., excavator or backhoe) is utilized to remove soil in designated lifts creating a test pit. This test pit is usually a narrow excavation (relative to its width) made below ground surface. Personnel gather various data from the test pit without entering the excavation unless appropriate engineering/safety controls are implemented. The test pit is then properly backfilled and closed.

The field team is responsible for the accurate and uniform collection of soil samples and for completing consistent, accurate, and uniform lithologic descriptions.

What to Bring

- Field book
- Test pit log sheets
- Map/site plan
- Indelible marking pens or markers
- Personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags
- Caution tape
- Measuring tape with weight (0.1 foot increments)
- Applicable air monitoring equipment (per the HASP)
- Camera
- Polyethylene sheeting (unless supplied by contractor)
- Sample container labels
- Chain of custody (COC) forms
- Soil sampling supplies
- Equipment decontamination supplies
- Sample coolers
- Ice (for sample storage/preservation)
- Zip-loc® plastic bags (for ice and COCs)
- Trash bag
- Survey equipment and/or GPS (means of establishing sample locations)

Office

- Prepare/update the project HASP; make sure the field team and field contractors have been provided the latest version.
- Review project-specific work plan for sampling and analytical procedures.
- Verify with the contractor that proper utility clearances/mark-outs have been completed at planned test pit locations.
- Determine if private utility survey/mark out is required for private property not included in public utility clearance.
- Discuss the objectives for the sampling program with the Project Manager and/or the field team leader.
- Discuss test pit order, sample collection method, designation, analytical parameters, turn-around times, laboratory, etc.
- Discuss field decontamination procedures and collection of investigation derived wastes.
- Review spoils pile segregation and stockpiling.
- Notify contractor of any heavy equipment decontamination responsibilities (e.g., power washer, drums, kiddie pool).
- Confirm that all necessary sampling and monitoring equipment is available in-house or has been ordered.
- Review sample bottle order for accuracy and completeness and submit to laboratory.

On-Site

- Verify that underground utilities have been marked out and that the mark-outs are clear. Sketch and photograph mark out buried utility locations.
- Identify if any overhead utilities, obstructions or limited access areas exist near proposed test pits and contact the Project Manager if any proposed locations need to be moved.
- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Establish a designated heavy equipment decontamination area, as needed.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- All intended hand signals to be used during the excavation should be reviewed and understood between the TRC personnel directing the operation and the equipment operator(s).
- Calibrate any field monitoring equipment.

TEST PIT SAMPLING

Conducting the Test Pit

- The location and estimated total depth of the test pit should be identified in the site-specific work plan.
- Test pits are to be dug in a linear fashion and, in general, are rectangular in shape. Spoils should be placed a minimum of 2-feet from the anticipated edge of the test pit to minimize potential caving.
- TRC personnel observing spoil piles will not stand between the spoil pile and the test pit.
- In many cases, soil will be brought to the surface by the equipment operator, within the excavator bucket. When this is the chosen method, TRC personnel shall instruct the operator to lower the bucket to the ground and turn off the excavating equipment.
- Document field observations on a Test Pit Log or in the field book.
- Take photographs of the test pit and any observed features of interest.

Closure of the Test Pit

- Backfill and return the excavated area to the original grade. Compact down the backfilled soil in lifts and do not leave any surface holes or other surface tripping or debris hazards when completed.
- Stake, label, flag and/or collect test pit location measurements for future reference or surveying.
- If segregation of contaminated soil has occurred, the disposition of these soils should be in accordance with the site-specific work plan. Fill material utilized to replace this deficit must be in accordance with the site-specific work plan.
- As specified in the site-specific work plan, return the surface conditions to pre-excavation conditions (e.g., loam, seed, mulch, pavement, etc.).
- As specified in the site-specific work plan, any erosion and sedimentation structures utilized must remain in-place until the surface area has been stabilized (e.g., seed germination and plant growth to maturity, pavement replaced).
- Documentation of the site conditions upon demobilization of the site should be noted in the field book. High visibility fencing or barricades, caution tape and posted signs are mandatory for any excavation left open overnight.
- Photographs of the area are also recommended prior to field staff departure.

Waste and Disposal

- Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.
- Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work.

Data and Records Management

- Record the general sample collection information such as location, depth, identification, and date/time in the field book or on a Test Pit Log.
- Typical field book or Test Pit Log documentation includes:
    - test pit dimensions and location;
    - measurements by tape measure or GPS coordinates and coordinate system;
    - visual or other sensory description of the samples (e.g., odors, staining);
    - soil descriptions (e.g., color, texture, appearance);
    - depth to the groundwater table if encountered;
    - any field screening results;
    - field duplicate location; and
    - photographs taken.
- Affix a properly completed label to each sample container.
- All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the site-specific work plan must be approved by the Project Manager and documented in the field book.

Title: **Asbestos Inspection Procedures**	Procedure Number: **BSI 003**
	Revision Number: **02**
	Effective Date: **March 2016**

Authorization Signatures

Technical Reviewer	Date	BSI Practice Quality Coordinator	Date
Edward A. Gerdts, CIH, CSP, LEED AP	3/16/16	Elizabeth Denly	3/16/16

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Page No.

ATTACHMENTS

Attachment A Asbestos Inspection Field Data Sheet
Attachment B Bulk Sampling Chain-of-Custody Form

1.0 INTRODUCTION

1.1 Scope & Applicability

TRC performs asbestos surveys for clients based on their specific project requirements and therefore the scope of an asbestos survey can range from a very limited sampling effort, such as determining if one specific suspect material is an asbestos containing material (ACM), to a comprehensive pre-demolition intrusive investigation for all suspect ACM. This standard operating procedure (SOP) establishes standardized procedures for TRC personnel who conduct asbestos inspections. Since not all projects require comprehensive investigations, not all procedures identified in this document need to be implemented on each project; rather this SOP provides a framework for TRC personnel performing inspections to reference based on the particular scope of work. This SOP outlines protocols, methodology, training and quality control to inspect, sample, analyze, assess and document asbestos-containing building material surveys. Local- or regional-specific training, inspection, sampling, etc. requirements are not addressed in this SOP; rather these will be addressed by a local or regional supplement to this SOP or as part of the project-specific agreement. The project-specific work plan (or equivalent) must be consulted to verify inspection requirements and details, as specified by the contractual agreement with the client.

This SOP is applicable to all Building Sciences and Industrial Hygiene (BSI) asbestos inspection programs, unless otherwise noted in project documents.

1.2 Summary of Method

The objective of an asbestos inspection is to identify the type and location of suspect ACM within a structure. Many times the asbestos inspection includes determining the quantity, condition assessment, accessibility and other factors that would aid in managing the ACM. The procedure typically involves on-site visual inspection, collection of bulk samples of suspect materials, laboratory analysis of collected samples, and reporting of the results of the inspection.

As there are significant health effects associated with the exposure to asbestos, asbestos inspections are utilized to help a building owner prevent exposure to asbestos fibers by identifying where the ACM is in their facility.

1.3 Equipment

The following list of equipment may be utilized when conducting asbestos inspections. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) such as Kevlar or cut-resistant gloves, safety glasses, half-face air purifying respirator with P100 filter, Tyvek, safety boots, hard hat
- Flashlight
- Sampling tools (retractable knife, hammer, chisel, screwdriver [flat-head and Phillips head], pliers, pry bar, drills, core sampling tubes)
- Zip-loc bags or other sealable sampling containers
- High Efficiency Particulate Air (HEPA) vac

- Clipboard, graph paper, Sharpie, pencils
- Tablet or smart-phone for capturing field data
- Spray bottle with amended water
- Measuring tape/roller
- Duct tape
- Baby wipes

1.4 Definitions

AHERA – The Asbestos Hazard Emergency Response Act, 15 U.S.C. 2646 et seq., and the regulations promulgated hereunder, including 40 CFR Part 763.

Asbestos-Containing Building Material (ACBM) – Any surfacing, thermal systems, insulation, or miscellaneous ACM found in or on structural members or other building components.

Asbestos-Containing Construction Material (ACCM) – California term for a manufactured construction material containing greater than 0.1% (one tenth of one percent) asbestos.

Asbestos-Containing Material (ACM) – Any material or product which contains more than 1% asbestos.

Functional/Area/Location/Space – Spatially distinct units within a building which contain identifiable populations of building occupants.

Homogeneous Area – An area of surfacing, thermal systems insulation, or miscellaneous material that is uniform in color and texture.

Inspection – Any activity undertaken in a facility or location for the purpose of determining the presence, location, and/or condition of friable or non-friable ACM or suspect ACM, whether by visual or physical examination, or by the collection of samples of such material.

Non-Friable Organically Bound (NOB) Material – A wide variety of non-friable building materials embedded in flexible to rigid asphalt or vinyl matrices. This includes vinyl asbestos tiles, mastic, asphalt shingles, roofing materials, paint chips, caulking and glazing, etc.

Presumed ACM – Asbestos-containing thermal system insulation and surfacing materials found in a building constructed no later than 1980 (OSHA regulations).

Point Counting – An analysis that is required to be performed when analyzing samples collected from buildings or operations covered by U.S. EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. A sample where no asbestos is detected by polarized light microscopy does not have to be point counted provided a minimum of three slide mounts are prepared and examined to confirm no asbestos has been detected; if the analyst detects asbestos in the sample and estimates the amount by visual estimation to be less than 10%, the owner or operator of the building may either assume the amount to be greater than 1% and treat the material as ACM, or require the verification of the amount by point counting.

Polarized Light Microscopy (PLM) – An optical microscopy technique for analyzing bulk samples for asbestos in which the sample is illuminated with polarized light (light which vibrates in only one plane) to distinguish between different types of asbestos fibers by their shape and unique optical properties.

Transmission Electron Microscopy (TEM) – A method of microscopic analysis which utilizes an electron beam that is focused onto a thin sample. As the beam penetrates (transmits) through the sample, the difference in densities produces an image on a fluorescent screen from which samples can be identified and counted.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. TRC personnel will use the appropriate level of PPE as required. The Project Manager or TRC's Safety Director can address any questions or safety concerns. Project-specific safety considerations should be documented in the project work plan (or equivalent). All employees performing asbestos surveys and inspections must consider the following:

- When working with or around asbestos, proper PPE should be worn.
- Inspection/sampling can be conducted at heights and fall protection may be required to access the sample location.
- Inspection/sampling may be conducted in confined spaces and proper confined space entry procedures may be required to access the space.
- Inspection/sampling may occur in abandoned/unsound buildings, poorly lighted spaces and under excessive hot or cold conditions requiring property-appropriate PPE planning and job hazard assessment.

Each inspector will be afforded with PPE, including the following:

- Half-face respirator with HEPA filters
- Spare HEPA filter cartridges
- Hard hat
- Safety glasses
- Hearing protection
- Safety boots
- Disposable protective clothing
- Vinyl or nitrile gloves

Personnel should wear a half-mask respirator equipped with P100 filters whenever collecting bulk samples of friable materials and where airborne fiber release is possible. If a higher protection factor is necessary or desired, wear a Powered Air Purifying Respirator (PAPR). Disposable protective clothing should also be worn to prevent contamination of street clothing when surveying such areas such as boiler rooms, mechanical spaces or crawl spaces where contamination is present. When sampling overhead, the inspector should wear suitable head covering. The use of hard hats, safety glasses and hearing protection will be determined on a case-by-case basis. A site-specific job hazard assessment should be conducted prior to each survey.

1.6 Cautions and Potential Problems

- Caution must be used when entering abandoned buildings or any unoccupied spaces. Potential hazards to be aware of include unauthorized occupants, structural issues (i.e., large parts of floor missing), rodents/animals, insects, confined spaces, guano/feces, poison ivy/oak, electrical hazards, slip/trip/fall hazards, etc.

- Some situations may require a second inspector to foot a ladder, etc. Prior to the site visit, potential hazards should be addressed.
- The inspectors should be aware that other contaminants may also be present and should take appropriate cautions: Examples include polychlorinated biphenyls (PCBs) in caulk, volatile organic compounds (VOCs), lead, and mercury switches (especially in power plants).
- Sampling of suspected ACM from live building systems such as electrical wiring insulation, steam pipes, and otherwise energized systems may require deactivation and isolation of the systems prior to sampling. TRC employees must have these systems de-energized by an appropriately trained professional prior to sampling.
- High temperature locations may require additional planning to ensure inspector safety while wearing PPE.

1.7 Personnel Qualifications

To help ensure that reliable results are obtained, all persons performing asbestos surveys and inspections must read this SOP and have an understanding of the contents and must complete 24-hour EPA AHERA Asbestos Inspector Training, along with subsequent 4-hour annual refresher training, and obtained as applicable, the asbestos inspector licenses/certifications for the state, county, municipality the survey/inspection is being performed in. It is required that a person conducting asbestos surveys and inspection for the first time does so with supervision from an experienced asbestos inspector.

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- OSHA 10-hour Construction Industry Outreach Training
- 8-hour annual HAZWOPER refresher training.
- Site-specific safety training

2.0 PROCEDURES

2.1 Pre-Survey Information

Prior to the initiation of the field survey portion of an asbestos inspection, a project meeting will be held to discuss the project scope and responsibilities (e.g., 40 CFR Part 763 AHERA, modified/enhanced AHERA format, NESHAP, Limited Scope survey, OSHA HazCom, etc.), staffing, schedule, deliverables, laboratory analysis, and potential problems that might be anticipated. The proper organization and planning of a project will help ensure that the work is accomplished in the most efficient manner. The Project Manager should request the following information from the client prior to the inspection:

- Name of on-site contact person
- Survey schedule
- One or more sets of building prints/floor plans
- Occupancy status

- Construction/renovation history of the building
- Results of any previous asbestos surveys performed at the facility

The Project Manager should also schedule an appointment or telephone conversation with the client to discuss the specifics of the survey scope prior to its initiation. The Project Manager should confirm that the client has arranged for an escort, as necessary, to provide access to all building areas for the survey team. If the client is to provide ladders for the survey team, their availability can also be ascertained at this time. The Project Manager should also determine if there are restrictions on the survey such as taking pictures, roofing access, confined spaces, and/or building-restricted access due to security, keys or escort requirement, occupancy, limitation on destructive survey and sampling, etc.

2.2 Building Systems

When designing a building, the design team is typically faced with limitations such as a budget, building code regulations, occupant and functional requirements. As a consequence, the physical layout of buildings is usually simple, with the structural systems being repetitive and the mechanical and electrical systems being served with minimal runs of ductwork, piping and conduit.

In multi-storied buildings the systems are typically simplified vertically. Generally, a utility core runs vertically through the building. From this core, service runs through branches to the individual floors. Elevators are generally bundled, and stair towers run vertically through the structure. The structural system is aligned vertically to simplify the skeletal frame. By simplifying the physical plan layout, the design team is able to achieve greater benefit with the restrictions placed on the project.

The inspector should have a broad base of knowledge of building systems as a requirement for performing asbestos inspections. Inspectors with extensive knowledge and experience with different types of building systems complete asbestos inspections with greater efficiency and thoroughness.

ACM has historically been used in many applications within buildings. The following subsections provide an overview of some of the building systems and types of suspect ACM that may be encountered as part of an asbestos survey.

2.2.1 Heating, Ventilation and Air Conditioning (HVAC) Systems

Individual spaces or zones in a building are on many occasions served by supply and return air and a thermostat to activate the HVAC system. The supply and return may be in ductwork or in an air plenum. An air plenum is an un-ducted space, such as the space above a suspended ceiling tile system and below the roof or floor above, which forced air passes through. Raised computer room flooring may also serve as a plenum in some server rooms or datacenter applications. In most cases, the plenum is used for return air (air that leaves the room, enters the plenum, and is drawn/forced into the mechanical room).

HVAC systems consist of a means of heat transfer. The heat transfer may occur in the central mechanical space or "plant", but in large buildings or complexes, it will occur in individual mechanical rooms. From the mechanical room, the supply air is delivered to individual spaces within the building and the return air is carried back to the mechanical room where it is filtered and re-conditioned. In addition, some make-up air is added to augment air lost through openings in the building such as doors and windows. This additional air also "freshens" the building air by providing outside air.

Heating and/or cooling of indoor air are both called air conditioning. For this reason, you are likely to find "Air Conditioning Plans" included in the sets of working drawings for both heating and cooling systems. The precise HVAC system layout and distribution is a product of architectural design and engineering analysis of the building.

HVAC systems can be classified as follows:

- Air Systems
- Water Systems
- Refrigerant Systems
- Radiant Systems

AIR SYSTEMS

There are two types of air HVAC systems – single duct and double duct (this refers only to supply ductwork; return is accomplished in yet another duct or plenum). A single duct system delivers either heated or cooled air based on the rooms' needs. Often a variable air volume system is used; wherein the air conditioning requirements of a space activate a damper that controls air flow based on these requirements. A terminal reheat unit, located near the port of discharge, may also be used to boost heating.

When a double duct system is used, one duct carries cooled air while the other carries heated air. The two ducts meet at a mixing box prior to being discharged into a room or other functional space.

WATER SYSTEMS

Heated and/or cooled water is delivered to a fan coil unit where the air is introduced. Air blown across coils as regulated by dampers, is again activated by requirements of the room or space.

Water systems are either two or four pipe systems. A two pipe system has a single supply and a single return pipe. With two pipes, it is possible to either heat or cool at a given time, but not both at the same time. However, floors with mixed occupancy or exposure to more than one point of the compass often require heating and cooling at the same time.

Four pipe systems deliver both heated and cooled water (called "chilled water") at the same time. Two pipes supply and return chilled water. The heat transfer coil may then call for whichever water supply is required to meet the needs of the space.

REFRIGERANT SYSTEMS

These are packaged units that supply heating or cooling directly to a space through a wall or roof. In general, these are used only in specialized installations in commercial buildings.

RADIANT SYSTEMS

Radiant systems include any number of devices which are embedded in the wall or floor assembly, or are set as radiators, usually along the exterior wall. They are usually used for heating and function by radiating heat directly into a space. That is, no air is blown across the heat transfer surface.

Since the primary function of the HVAC system is to heat and cool building spaces, insulation is used to inhibit unwanted heat transfer. Suspect ACM insulation is typically found on the outside of boilers (block, board or wrap insulation) inside the boiler unit (refractory, interior wall insulation, fire brick, mortar, etc.) and on the breaching or flue which conveys the waste gases from the combustion process. Blanket, batt or troweled-on insulation is sometimes found on the inside or outside of ductwork. In addition, gasket materials on boiler doors, rope used as filler in openings, valve packing, fire stop packing, and vibration dampening cloth connecting sections of ductwork may contain asbestos.

HVAC systems which use chilled water will typically use a cooling tower where excess heat is released to the outside air. The chilled water does not pass through the cooling tower, but rather tower water from the chiller passes through the tower. Cooling tower baffles and sometimes filter media (fill) are constructed with ACM; the slats are typically asbestos-containing board (transite).

2.2.2 Plumbing Systems

Plumbing systems include water, gas, or other fluid which is piped through a building, and in some cases, disposed of as waste. Also considered part of the plumbing system is air when used in a non-HVAC manner, such as compressed air in hospitals. The system consists of piping; horizontal pipes are called runs and vertical pipes are called risers.

The water systems in a building are of four types: consumed, circulated, static, and controlled. The consumed system is for potable water for use and consumption by building occupants. Circulated water is water which is circulated from a “plant” to the HVAC equipment in two or four pipe systems. Static water is used for fire protection and controlled water is water used to maintain relative humidity within the building.

The use of asbestos in plumbing systems is usually for the purpose of temperature control. Generally it is found on hot water pipes. You may find insulation on cold water pipes as condensation control. The heating point as well as some hot water pipes away from the source may also have asbestos-containing insulation. As a pipe travels through the building, it can quickly lose heat. Insulating the pipe in sections along the pipe runs will help ensure that the last space on the line will get hot water.

In addition to surrounding the pipes, the pipes themselves may be concrete-like in appearance and are known as transite. Cement-like pipes are generally used for wastewater and roof drainage. Metallic roof drains may also have asbestos insulation to prevent condensation

2.2.3 Electrical Systems

Electrical systems in a building may appear very complex, but are simple in their basic design. Each building contains an electrical service entrance; the point where energy enters the building. This is usually where the electrical meters are located.

In large buildings, transformers will be set onsite to reduce the high voltage supply from the electric company to the lower voltage used within the building. In smaller buildings, this transformer will be outside the building on a concrete pad or utility pole. Once the voltage has been reduced, the service is then divided into individual circuits. The size and capacity of each circuit is based on the anticipated energy requirements of the items served by that circuit. The division of electricity into circuits takes place at the circuit panel(s).

Electrical cable runs may be carried by transite ducts. Partition in the electrical panels may also be transite or asbestos board while the entire panel may be mounted on an additional transite panel. Asbestos cloth may also be used to bind and insulate wires or cables. Schools and theatres provide numerous sources of asbestos, particularly in stage lighting, lighting booths where the spotlight is located, and packed insulation around cables. Asbestos gaskets may also be present in other lighting systems.

2.2.4 Structural Systems

The structural system of a building is the "skeleton" or support of the building. This includes support columns, steel decking separating floors, and support beams. It may also include cement or concrete structures constructed for added support.

Fire in a building can be devastating. It is all the more so should the steel supports buckle and collapse under intense heat. The same holds true for the steel decking supporting each floor and the support beams under that decking. Spray-applied fireproofing material is necessary to maintain the integrity of the steel and to contain the fire to one floor. Support columns are often covered in sheetrock to hide the rather ugly appearance of spray-applied fireproofing material. The support beams and decking are also hidden behind a ceiling material including plaster and/or suspended ceiling tile systems.

2.3 Inspection Procedure

The inspection process focuses on identifying (1) surfacing materials; (2) thermal systems insulation; and (3) miscellaneous materials, all of which are likely or suspected to contain asbestos. These materials may be located in the building drawings or seen during the walk-through. Once located, the materials are divided into homogeneous areas/materials, sampled, and analyzed. Those materials which are not sampled, yet are suspect, must be presumed to contain asbestos. The next step is to identify functional spaces/locations for purposes of documenting the location of ACBM and to aid in the assessment process.

The job of the inspector is to locate friable and nonfriable ACBM. To confirm whether or not a material contains asbestos, the inspector has two choices: sample and analyze a suspect material or presume the materials contains asbestos. Any building material can be assumed to contain asbestos as long as the material is handled as if it were asbestos. The presumption of asbestos must continue until samples are taken and analyzed to confirm or refute the presence of asbestos. For hazard communication purposes the OSHA asbestos standards require all surfacing, thermal systems insulation and flooring installed before 1980 to be presumed asbestos-containing material (PACM) until sampled and proven otherwise. That said, it is possible for buildings built after 1980 to contain ACM, particularly in flooring and roofing materials. For renovation/demolition, the EPA Asbestos NESHAP requires all suspect material to be treated as ACM, regardless of age, until proven otherwise.

The inspection process can be summarized as follows:

1. Review previous sampling reports/surveys and abatement records, when available.
2. Interview relevant building personnel (e.g., building engineer, building manager, etc.).
3. Review building drawings and construction documents.
4. Perform a walkthrough inspection.
5. Locate functional spaces/locations.
6. Locate suspect material and determine homogeneous areas/materials.
7. Develop sampling scheme; sample and analyze.
8. Assess condition of known and assumed ACBM.
9. Document locations and quantities of ACBM.

PREVOUS SURVEYS AND ABATEMENT RECORDS

Previous building inspections and abatement activities may have been performed in a building. The inspector should review previous sampling information and incorporate the results into the survey. If previous surveys indicate a material is asbestos containing, supplemental sampling is not necessary to classify the material as asbestos containing; however, additional testing may be used to delineate the extent of the ACM. Previous abatement records may also indicate additional areas which contain suspect materials or may serve to document a material has been removed. Caution should be taken when reviewing and utilizing previous surveys to ensure the data developed meets the current regulatory requirements, including specific analytical requirements which may change over time.

BUILDING DRAWINGS AND CONSTRUCTION DOCUMENTS

Construction documents are the legally binding drawings and specifications which are used to construct the building. They consist of working drawings, specifications, addenda, change orders, shop and as-built drawings. The working drawings or plans are a set of drawings which indicate the finished appearance and may be a source of information for inspectors. The working drawings do not precisely reflect the building as it was constructed. An inspector must review all addenda to see the building in its current condition.

Architectural Drawings – The architectural drawing shows the finished surfaces and materials on the floor plan. Be aware that the room designations depicted on the drawings may be different from the actual room number scheme used by the occupants or the owner. The inspector should use the numbering scheme with room names familiar to the occupants.

Structural Drawings – Structural drawings will consist of foundation plans, floor framing plans, roof framing plans, structural elevations, details, notes, and schedules. Structural drawings indicate the structural elements of the building and use a structural grid to identify support columns, support beams, etc.

Mechanical Drawings – Mechanical drawings consist of mechanical system plans, based on the building floor plans, for both the HVAC systems and the plumbing system. They indicate the routing of the ductwork and piping systems as well as the details, notes, etc.

Electrical Drawings – Electrical drawings indicate light fixtures, electrical panels, indoor transformers, mechanical rooms, etc., and will orient the inspector with their locations.

As-Built Drawings – Many times during the course of construction, interferences arise between building systems which will not permit a pipe run or a window, etc., to be installed where indicated on the plans. In this case, the plans are modified in the field to indicate the new location or modifications required to overcome the interference. The plans or details are called "as-built" drawings and are intended to record the modifications for future reference. The as-built drawings may explain discrepancies the inspector finds in the field, compared to the drawings the inspector reviewed prior to the inspection.

WALKTHROUGH INSPECTION

The physical inspection should begin with a walkthrough of the entire building or area to be surveyed. A thorough review of building records prior to the inspection may help locate suspect materials and access to these materials. All areas, including the space above dropped ceilings in each room, crawlspaces, tunnels, mechanical areas, roofs, basements, attics, and air plenums may be part of each inspection based on the client-specific scope of work.

Notes describing the type, estimated quantity and condition of suspect ACBM should be made on an Asbestos Inspection Field Data Sheet, or equivalent (Attachment A). Site sketches/drawings should be recorded in a manner which conveys the information accurately.

HOMOGENOUS MATERIALS

The suspect ACBM should also be assigned a homogeneous material number or ID (e.g., PI1, FT4, PL2, etc.). A homogeneous material is a material encountered during the inspection which is like in color, texture, use, and age (e.g., installation/construction date). Suspect materials similar in appearance but found in different areas of the building which were constructed at different times should be considered different homogenous areas/materials, unless building records indicate application at the same time.

Standard type terminology should be used on the Asbestos Inspection Field Data Sheet, sketches, notes, and in the data tables included in the final report. ACM should be identified using terminology such as:

- Pipe insulation
- Mudded pipe fitting insulation
- Boiler insulation
- Tank insulation
- Troweled-on surfacing material
- Floor tile mastic
- Plaster base coat
- Wallboard / Drywall
- Cement board
- Cove base
- Transite
- Window caulk
- Galbestos
- Carpet mastic
- Duct insulation
- Boiler breeching insulation
- Spray-applied fireproofing
- Floor tile
- Ceiling tile
- Plaster skim coat
- Joint compound
- Glue daubs
- Cove base mastic
- Roofing / Flashing
- Window glaze
- Vermiculite attic insulation

The inspector should divide all suspect materials into one of three AHERA categories and one of three NESHAP categories:

AHERA

Surfacing Material means material that is sprayed-on, troweled-on or otherwise applied to surfaces, such as acoustical plaster on ceilings, fireproofing materials on structural members, or other materials on surfaces for acoustical, fireproofing or decorative purposes.

Thermal Systems Insulation means material applied to pipes, fittings, boilers, breaching, tanks, ducts, or other interior structural components to prevent heat loss or gain, water condensation, or for other purposes.

Miscellaneous ACBM means building material not classified as thermal systems insulation, surfacing material, wood, fiberglass, glass, plastic, metal, or laminate.

NESHAP

Friable – A material, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure, and includes previously nonfriable material after such material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure.

Category I Non-Friable – Asbestos-containing packings, gaskets, resilient floor covering and asphalt roofing products containing more than 1% asbestos. Category I nonfriable ACM has been interpreted to include pliable asbestos-containing sealants and mastics since they exhibit many of the same characteristics of Category I nonfriable asbestos-containing materials

Category II Non-Friable – Any material, excluding Category I nonfriable ACM, containing more than 1% asbestos that, when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure. (Example: asbestos-cement products)

FUNCTIONAL AREA/LOCATION/SPACE
Functional area/location/space designations used on the Asbestos Inspection Field Data Sheet/notes should correspond to the functional areas/locations/spaces identified on the building drawings (or rough field sketch if building drawings are not available). In areas where physical access is impossible by the inspector (e.g., pipe chases), every effort should be made to estimate the presence, location, quantity and condition of the material.

2.4 Bulk Sampling Procedure

The following steps are the typical sequence involved in bulk sampling for asbestos:

- **Identify suspect ACM and assign a homogeneous area/material number/ID.** A homogeneous area contains material that is uniform in use, in texture and appearance, was installed at one time, and does not consist of more than one type, or formulation, of material.
- **Determine the number of samples.** The proper number of samples is based on the type of material and the size of the sample area.
- **Determine the sampling locations.** The locations are chosen to obtain a representative sample and avoid biases that could be introduced if personal judgment alone was used.
- **Collect samples.** Follow guidelines designed to minimize fiber release. Properly label sample containers with a unique sample identifier.
- **Send the samples to a qualified laboratory** for asbestos analysis using proper sample chain-of-custody procedures; include desired turnaround time for results and the appropriate project number.
- **Interpret and document the results.** If any sample in the homogenous area/material series has more than 1% asbestos, then either assume the entire homogenous area/material is an ACBM or collect additional samples to determine more precisely the extent of the ACBM and distinction in homogenous areas/materials.

2.4.1 Identify Suspect ACM

Suspect materials in the work area, as per the scope of work, must be identified. Check all spaces in the work area, including halls, closets, attic spaces, pipe chases, and tunnels. Carefully inspect walls, ceilings, beams, ductwork, floors, and other surfaces. ACBM is sometimes found in areas deemed inaccessible (e.g., behind walls, false ceilings, pipe chases, etc.). Sampling in these areas requires cooperation with the work area owner due to the destructive methods that may be necessary to reach the material. Identify areas that were part of the work that could not be accessed.

Several types of suspect ACM may have been applied within a single area of a building. If the function/use of a material is different, the inspector should consider them separate homogeneous areas/materials (e.g., ceiling plaster vs. plaster on a wall where one is cosmetic and one may be acoustical).

If there is any reason to suspect that materials might be different, even though they appear uniform, assign them to separate homogeneous areas/materials. For example, materials in different wings of a building, on different floors, or in special areas such as cafeterias, machine shops, band rooms, etc., might be assigned to separate homogeneous areas/materials.

Unless mandated by state or local regulations, in a large multi-story building, a separate homogenous area for each floor may not be necessary. If the material appears identical on every floor, several floors can be grouped into one homogeneous area. Do not group floors if it is known that the material was applied at different times, or if there is some reason to suspect the material might not be homogeneous. When in doubt, assign materials to separate homogeneous areas/materials.

Specific building materials in accordance with AHERA protocols that do not require inspection, sampling, and analysis for asbestos include: wood, fiberglass, foam glass, glass, rubber, plastic, and metal.

It is prudent to assume that every survey has its limitations in that there cannot be a guarantee that all ACBM, as it relates to the project or scope of work, will be located or identified during any single inspection. As a general rule, it is the inspector's responsibility to locate, sample and assess all ACBM. This may involve "destructive sampling" prior to building demolition of areas not usually accessible by the inspector. Appropriate contract and report language for limiting liability associated with sampling and failure to detect inaccessible asbestos should be used where appropriate, such as:

- Sampling was performed on a random basis and the material was assumed to be homogeneous. The possibility exists that the material composition may differ from where the samples were taken.
- Only exposed materials have been sampled. Some concealed or difficult to reach suspect ACBM has been included in the survey based upon certain assumptions or may remain undiscovered.
- Before any abatement or major renovation is undertaken, additional sampling may be required to verify the exact extent of the ACBM.
- TRC is not responsible for damaged materials due to destructive sampling when this sampling is employed based on the contract or scope of work.

The inspector must document the inaccessible areas or limitations on the inspection so as to document areas which could not be evaluated during the testing. These limitations must be incorporated into any report of the sampling activity.

2.4.2 Number of Samples

Bulk samples must be collected by an EPA trained/accredited and state licensed (if applicable) asbestos inspector as prescribed below, in a satisfactory random manner such that they are representative of each homogenous area/material not to be assumed ACM. Unless otherwise stated in client agreement, sample quantities per homogenous area/material shall at a minimum be in accordance with EPA AHERA sampling protocols and guidance interpretation. As noted below, however, certain states or location standards may impose further or different stipulations to be followed.

SURFACING MATERIALS

In a randomly distributed manner, collect bulk samples of surfacing materials, representative of each homogeneous area, not assumed to be ACM.

1. Collect at least three bulk samples from each homogeneous area/material that is less than or equal to 1,000 ft^2.
2. Collect at least five bulk samples from each homogeneous area/material that is greater than 1,000 ft^2, but less than or equal to 5,000 ft^2.
3. Collect at least seven bulk samples from each homogeneous area/material that is greater than 5,000 ft^2.

NOTE: When any doubt exists as to the quantity of material, the inspector should collect sufficient samples to characterize the largest potential quantity.

THERMAL SYSTEMS INSULATION

1. In a randomly distributed manner, collect at a minimum, three (3) bulk samples of thermal systems insulation material, representative of each homogeneous area/material, not assumed to be ACM.
2. Collect, at a minimum, one (1) bulk sample of patched thermal systems insulation, representative of each homogenous area/material, not assumed to be ACM, providing the section of patch was less than 6 linear or square feet.
3. Collect, at a minimum, three (3) representative bulk samples of each insulated mechanical system not assumed to be ACM, where cementitious material is used on pipe fittings such as tees, elbows, or valves, conducted in a manner sufficient as to identify whether each homogenous area/material is either asbestos or non-asbestos containing.
4. Bulk samples are not required to be collected from any homogeneous area/material where the accredited asbestos inspector has determined that the thermal systems insulation is a non-suspect material (i.e., fiberglass, foam glass, rubber, or any other non-suspect material).

MISCELLANEOUS MATERIALS

1. In a randomly distributed manner, collect at a minimum:
   - Two (2) bulk samples of miscellaneous material, representative of each homogeneous area/material, not assumed to be ACM, conducted in a manner sufficient as to identify whether each homogenous area/material is either asbestos or non-asbestos containing.
   - One (1) sample if the amount of miscellaneous material is less than 6 square or linear feet.

NOTE: Project-specific or state-specific requirements may supersede these requirements.

2.4.3 Selection of Sample Locations

Sample locations should be selected randomly so that they are representative of the sampling area. A random sampling scheme can be used to determine their location; however many times sampling locations are ultimately determined by site conditions and project and client restrictions. Note that choosing sample locations according to personal judgment or accessibility alone may produce samples which may not be statistically representative and therefore locations should be selected randomly to the extent feasible.

2.4.4 Documentation of Sampling

Each sample location must receive a unique sample ID which can consist of the homogeneous area number/ID, sample number and corresponding sample location. This sample ID will be on the sampling container when it goes to the laboratory for analysis. Record the ID number and location on the Asbestos Inspection Field Data Sheet, sketches and/or notes prior to submission to the laboratory. This must be done carefully so that there is no uncertainty about the location and identity of each sample. Make sure that no two samples have the same sample ID. Each sample shall be recorded using a sample chain-of custody log, with all pertinent information regarding client, site, date, time, sample ID, homogenous area/material, sample location, inspector, layers, requested analysis, turn-around time, etc., signed/dated by the inspector when sample custody is transferred to the laboratory.

2.4.5 Collection of Samples of Suspect Materials

The following guidelines for sample collection are designed to minimize the damage to ACBM and possible airborne fiber release, while allowing for proper representative samples to be collected:

- Collect samples while an area is unoccupied.
- At a minimum, wear non-slip, rubber soled shoes (i.e., depends on work or site conditions).
- Wear at least a half-face respirator with disposable P100 filters. If a higher protection factor is necessary or desired, wear a PAPR.
- Wet the surface of the material to be sampled with amended water mist from a spray bottle or place a plastic bag around the sampler with the open end of the bag pressed tightly against the wall or ceiling.
- With a cutting or coring utensil, penetrate material completely to the substrate to obtain all possible layers. Be sure to penetrate any paint or protective coating and all layers of the material. If a knife is used, make sure to insert the blade all the way into the material and cut a small triangular core out of the material. Ensure enough material is sampled for PLM and potential TEM analyses. Material sampled should be at least the size of a nickel.
- Place sample into a Zip-loc bag or other laboratory-supplied sample bag and seal. Alternate containers should be lightweight, easily carried, and stored and sealable. Containers that may break, tear, or lose their lid if accidentally dropped shall not be used.
- Label the container using a permanent marker or equivalent with unique sample ID, location where the sample was collected, inspector initials, date and time. Use the sample ID that is marked on the Asbestos Inspection Field Data Sheet, sketches, notes, and chain-of-custody. Labeling the sample location using duct tape or pre-made labels and indelible marker may be a requirement of the specific project scope.
- Double-bag all samples by placing them in a larger Zip-loc bag or sealed plastic bag before transporting.

2.4.6 Repair of Sample Location

After collecting the sample, the sampling point may require repair to prevent fiber release. In such cases, completely fill in the hole from which the sample was collected. To repair a roof sampling location, a cold patch material, or EPDM repair kit, may be used. If roof warranties are required to be maintained, it may be necessary to have a certified roofing contractor perform the repair work. This condition should be discussed with the client prior to sampling.

- Use latex spray paint or similar sealant or a bridging material such as plaster, caulk, or other enclosure material such as duct tape to cover the spot where the sample was taken.
- In the case of thermal insulation, damage may be repaired by applying an encapsulant and wrapping with duct tape.

2.4.7 Decontamination after Sampling

Debris or dust produced during bulk sampling procedures must be cleaned up and adjacent surfaces must be decontaminated by the inspector. The affected area should be HEPA vacuumed or wet wiped to remove visible material deposited on surfaces. Small quantities of debris or dust may be cleaned with a wet rag and disposed of as asbestos-containing waste in properly labeled polyethylene bags.

2.4.8 Laboratory Analysis

Bulk sample analysis shall be performed in accordance with EPA's "Test Method for the Determination of Asbestos in Bulk Building Materials" (EPA 600/R-93/116, July 1993), at laboratories accredited by the National Voluntary Laboratory Program (NVLAP) and as applicable per state/local programs. Samples consisting of multiple layers (e.g., floor tile/mastic, plaster base/skim coat, sheetrock/joint compound, etc.) shall be analyzed as separate layers in accordance with EPA Federal Register Clarification Policy and OSHA Applicability Determinations. Samples shall be initially submitted for asbestos analysis via PLM with quantification via visual area estimation (vie). Samples of each homogenous area/material type shall be analyzed sequentially with a "positive stop" unless directed otherwise by project-specific or state/local requirements. Samples with detectable asbestos concentrations via vie quantifications below 10% may either be assumed to be ACM or may be further quantified using EPA's 400 point count (pt. ct.) quantification techniques at the discretion of the client. Sample concentration quantifications performed using 400 pt. ct. techniques shall supersede visual estimations in accordance with EPA Federal Register Clarification Policy. NOB samples may be elected to be prepared for analysis using Gravimetric Reduction Techniques to remove binder matrix interference as required or requested by client or state/local requirements, or where increased analytical precision is warranted. Confirmation of negative PLM results on NOB material sample types using TEM in order to confirm fiber sizes below the limit of detection of the PLM method may also be elected as required or requested by client or per state/local requirements.

2.4.9 Interpretation of Results

If one or more samples from a homogenous area/material has more than 1% asbestos, then the homogenous area/material should be treated as asbestos. If any doubt remains within the sampling area, additional samples may be collected to confirm the actual extent of the ACM.

Since a decision regarding the presence of asbestos can be made as soon as one sample shows more than 1% asbestos, the samples can be analyzed sequentially with a "positive stop". Note that materials can contain trace (1% or less) amounts of asbestos and not be considered ACM but are still regulated by OSHA, etc. (California also regulates ACCM). Continue in this manner until at least one sample is confirmed >1% asbestos or the minimum number of samples for the homogenous area/material has been analyzed to confirm the material is non-ACM.

2.5 Condition Assessment

As part of the inspection, the inspector should typically conduct a physical assessment of all confirmed and assumed ACBM. The physical assessment consists of assessing (1) the condition of the material and (2) the potential for future disturbance. In some cases this assessment is not necessary due to project or client specific requirements.

THE PHYSICAL ASSESSMENT
Assess the current condition of the ACBM. Assess the homogeneous material as it appears in each functional area/location space and provide assessment based on the individual space, not the homogeneous material as a whole.

Divide the assessment of the material's current condition into three categories; good condition, damaged or significantly damaged, as described below:

- **Good Condition** – Material with no visible damage or deterioration, or showing only very limited damage or deterioration.
- **Damaged** – Material which has deteriorated or sustained physical injury such that the internal structure (cohesion) of the material is inadequate or which has delaminated such that its bond to the substrate (adhesion) is inadequate, or which, for any other reason, lacks fiber cohesions or adhesion qualities…flaking, blistering, or crumbling; water damage, significant or repeated water stains, scrapes, gouges, mars or other signs of physical injury.
- **Significantly Damaged** – Means damaged ACBM in a space where the damage is extensive and severe. If the extent of the damage is greater than 10% of the material in an evenly distributed manner or greater than 25% of the material in a localized manner, then the material is significantly damaged.

The potential for future disturbance may also be assessed and is determined by the inspector as high, moderate or low with respect to potential contact vibration and/or erosion.

2.6 Drawings

For a survey scope where building drawings identifying ACBM and sample locations are one of the deliverables, the survey team will be provided with the building drawings, when available, prior to inspection. If drawings are not provided by the client, the inspector may be required to sketch the building at the time of the survey and note locations of samples collected and each suspect homogenous material location(s). The inspector should try and obtain a copy of the site plan while on site.

2.7 Photographs

Photographs may be taken where ACM have been identified, based on the requirements of the client and survey scope. When photographs are to be included in the report, they will be taken of homogeneous materials identified in the building. Photographs may also be taken in the following situations:

- **Imminent Hazard Situations** – Any areas where ACBM is observed to be significantly damaged in areas routinely accessed by building occupants.

- **Significantly Damaged Material** – Any damaged ACBM in a space where the damage is extensive and severe.
- **Unusual Situations** – Any situation where sketches or general field notes do not adequately describe the materials, configuration or other unusual circumstances.

Each photograph taken will include some type of labeling with the name or number of the space.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

The following list is a summary of the quality control procedures used to help ensure inspection and sampling accuracy and completeness:

- Quantities of samples of each homogenous material collected to determine asbestos content shall meet AHERA sampling protocol minimums, this SOP and any applicable state/local requirements, unless otherwise specified in client agreements.
- Laboratories utilized for asbestos bulk sample analysis may require NVLAP accreditation and may need to meet applicable state/local or client requirements.

4.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Recordkeeping and documentation procedures are described throughout this SOP and examples of an Asbestos Inspection Field Data Sheet and chain-of-custody form are presented in Attachments A and B, respectively.

5.0 REFERENCES

The Asbestos School Hazard Abatement and Reauthorization Act (ASHARA) - 15 USC 2641-2656.

Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Title 29; CFR, Section 1926.1101.

OSHA, U.S. Department of Labor (Respiratory Protection), Title 29 CFR Section 1910.134.

OSHA, U.S. Department of Labor (Access to Employee Exposure and Medical Records), Title 29, CFR, Section 1910.20.

OSHA, U.S. Department of Labor (Hazard Communication for the Construction Industry), Title 29, CFR, Section 1926.59.

Transportation, Title 49, CFR, Parts 171 and 172.

U.S. Environmental Protection Agency (EPA) Regulations for Asbestos, Title 40 CFR, Part 61, *National Emission Standards for Hazardous Air Pollutants (NESHAP),* Subparts A and M.

U.S. EPA *Asbestos Hazard Emergency Response Act (AHERA),* Title 40 CFR 763 Subpart E.

U.S. EPA Asbestos Model Accreditation Plan (Training of Asbestos Workers), Title 40 CFR 736 Subpart E Appendix C.

U.S. EPA Asbestos in Buildings: *Simplified Sampling Scheme for Friable Surfacing Materials*, October 1985 (Pink Book).

U.S. EPA Worker Protection Rule, Title 40 CFR 763 Subpart G.

Various State/Local Asbestos Standards/Regulations.

6.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JULY 2008	Not applicable.
1	JUNE 2012	Routine review and update. Expanded SOP to include additional procedural description and details.
2	MARCH 2016	Routine review and update to current TRC SOP format.

Attachment A

Asbestos Inspection Field Data Sheet

Results you can rely on

ASBESTOS INSPECTION FIELD DATA SHEET

Page___of___

Project #:____________________________
Name:____________________________
Location:____________________________

Inspector Name and License #:____________________________
Date of Inspection:________________
Inspector Signature____________________________

Attach sample location drawing to ALL inspection forms

Sample #	Material Description (include color) (Homogenous Area)	Material Location	Quantity (Area) (SF or LF)	Friable (NF or F)	Damage (ND, D, SD)	Photo #

Revised: November 2015

Attachment B

Bulk Sampling Chain-of-Custody Form

TRC
Results you can rely on

Edition: November 2015

ASBESTOS BULK SAMPLING CHAIN OF CUSTODY

TRC Office ______________

FedEx Airbill # ______________________________

Project Contact ______________________________
E-Mail ______________________________
Phone # ______________________________
LAB ID #. ______________________________

PROJECT NUMBER	PROJECT NAME	PARAMETERS	TURNAROUND TIME				
			PLM:	8hr	24hr	48hr	3day
			TEM:	24hr	48hr	3day	5day

SIGNATURE	INSPECTOR

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE LOCATION	PLM EPA 600/R93/116 (POSITIVE STOP)	PLM EPA 600/R93/116 (w/ gravimetric reduction) (POSITIVE STOP)	ANALYZE BY LAYER	EPA 400 POINT COUNT (IF >1% & <10%)	TEM NY NOB 198.4 (IF PLM SERIES NEG)	MATERIAL

Relinquished by: (Signature)	Date	Received by: (Signature)	Relinquished by: (Signature)	Date	Received by: (Signature)
(Printed)	Time	(Printed)	(Printed)	Time	(Printed)

Remarks:
☐ Analyze bottom layer first

Condition of Samples ______________
Acceptable Yes__________ No________
Comments

Page 1 of ___

Stormwater Visual Examination and Sampling Guide

Part 1: Visual Examination of Stormwater

Purpose: Visual stormwater examinations are typically required of facilities covered under National Pollutant Discharge Elimination System (NPDES) stormwater permits. This type of examination does not require sampling for chemical testing, but collection of a grab sample for examination of physical characteristics is required. This guide provides a general outline of the necessary equipment and steps required to perform a thorough visual examination.

Requirements:

- Visual examinations must be performed at each outfall that receives stormwater discharge from drainage areas containing industrial materials or activities, unless otherwise stated by the site-specific permit.
- Address any safety concerns in the sampling area (slips, trips, and falls; steep slopes; height issues; inclement weather).
- It is important to take samples from the *outlet* of any structural control measure as opposed to the *inlet*. This will determine the quality of water after any treatment has taken place. Samples should be taken from the center of flow of the outlet.
- Visual examination of stormwater must be within 30 minutes of a Qualifying Storm Event. A Qualifying Storm Event meets the following two requirements:
  1. Must have an intensity of at least 0.1 inch of rain or snowmelt in a 24 hour period,
  2. Must not have occurred within 72 hours of a previous storm event that generated 0.1 inches or more of rain.

Supplies:

- Visual Monitoring Form (may be included in the Stormwater Pollution Prevention Plan [SWPPP] or provided by the state in which the sampling is taking place).
- Clear, colorless glass or plastic bottle or jar with lid.
- Long handled dipper (only necessary if the middle of flow cannot be reached otherwise; the dipper can be improvised by attaching a clean cup to the end of a yardstick).

Instructions:

1. Within 30 minutes of a Qualifying Storm Event, while discharge is still occurring, collect a sample from the center of flow of the outlet. Only collect samples from water which is flowing at the time of collection.
2. Pour the sample into the clear container.
3. Document a description of the observed odor (e.g., petroleum, sulfur, etc.) on the Visual Monitoring Form and secure the lid. Note – odor can dissipate quickly.
4. Allow the sample to settle for at least 30 minutes, but no longer than an hour.
5. Record observations based on the following criteria on the Visual Monitoring Form.
   a. **Color** – Document the presence or absence of color. If the sample has any color, it could be an indicator of pollution.
   b. **Odor** – The presence of any odor should be documented in *Step 3*, before the sample is allowed to settle.
   c. **Clarity** – Note if the sample is clean, cloudy, or opaque.
   d. **Floating Solids** – Note the presence and composition of any floating solids in the sample.
   e. **Settled Solids** – Note the presence and composition of any settled solids in the sample.
   f. **Suspended Solids** – Note the presence and composition of any suspended solids in the sample.
   g. **Oil Sheen** – Check the surface of the water for a sheen. Biological sheens tend to be silver or dull in color and break into pieces and do not reform if disturbed. Hydrocarbon sheens tend to be rainbow colored and merge back together if disturbed.
   h. **Foam** – Secure the lid on the container and shake gently. Document the presence of a foam.
   i. **Other** – Include any other observations of the area. This might include negative indicators of stream health (i.e., debris, dead plants or animals) or positive indicators of stream health (i.e., thriving plant life, other biological activity).

Part 2: Sampling Stormwater

Purpose: Some facilities under a NPDES permit may be required to collect stormwater samples and submit them for laboratory chemical analysis. This guide provides a general outline of the necessary equipment and steps to properly collect a stormwater sample.

Requirements:

- Samples must be collected at each outfall that receives stormwater discharge from drainage areas containing industrial materials or activities, unless otherwise stated by the site-specific permit.
- Address any safety concerns in the sampling area (slips, trips, and falls; steep slopes; height issues; inclement weather).
- Stormwater sampling must occur within 30 minutes of a Qualifying Storm Event. A Qualifying Storm Event meets the following two requirements:
  1. Must have an intensity of at least 0.1 inch of rain or snowmelt in a 24 hour period,
  2. Must not have occurred within 72 hours of a previous storm event that generated 0.1 inches or more of rain.

Supplies:

- Sampling Kit – sampling kits are typically provided by the laboratory and include bottles, preservatives, labels, coolers and chain-of-custody forms.
- Disposable powder-free gloves – prevents contamination of samples.
- Watch – Used to record time.
- Fine-tip markers and pens – Used to label bottles and fill out chain-of-custody forms.
- Long handled dipper (only necessary if the middle of flow cannot be reached otherwise; the dipper can be improvised by attaching a clean cup to the end of a yardstick).

Sampling Instructions:

1. While wearing a clean pair of disposable gloves, collect a stormwater discharge sample from an outlet by facing the mouth of the bottle upstream, submerging half of the mouth of the bottle beneath the water table, and allowing water to enter directly into the bottle.
2. Do not sample from areas with little or no flow.

3. Do not touch the inside of the bottle or allow the bottle to touch the ground.
4. Fill the bottle to neck or as required for a particular analysis.
5. Cap and label the bottle as soon as it is collected. The label should include:
   a. Sample location
   b. Date
   c. Time
   d. Sampling parameter
   e. Preservative
6. Place samples in a re-sealable plastic bag.
7. Place the bag in a cooler containing ice. The samples should be kept close to 4°C until the cooler is delivered to the laboratory.
8. Complete the chain-of-custody form. The form should include the following information:
   a. Sample Number
   b. Location
   c. Type of sample (i.e., grab or composite)
   d. Matrix
   e. Method of analysis
   f. Preservative
   g. Date and time
   h. Sampler's signature
9. Put the chain-of-custody form in a sealed plastic bag and attach it to the inside of the top of the cooler.

Appendix B
TRC Field Activity and Sampling Forms

Table B-1: TRC Field Forms within Appendix B

Source	Form Title
TRC	Air / Vapor Sample Log
TRC	Groundwater Sample Log
TRC	Low Flow Groundwater Sampling Log
TRC	Residential Well Sampling Log
TRC	Soil Boring Log
NYSDEC	Structure Sampling Questionnaire and Building Inventory
TRC	Surface Water / Sediment Sample Log
TRC	Test Pit Log
TRC	Water and Product Level Monitoring Form
TRC	Well Construction Log – Flush Mount
TRC	Well Construction Log – Stick Up
NYSDEC CP-43	Well Decommissioning Record
TRC	Well Development Form
TRC	Monitoring Well Inspection Form

AIR / VAPOR SAMPLE LOG

<table>
<tr><td>PROJECT NAME:</td><td colspan="2">PREPARED</td><td colspan="2">CHECKED</td></tr>
<tr><td>PROJECT NUMBER:</td><td>BY:</td><td>DATE:</td><td>BY:</td><td>DATE:</td></tr>
</table>

<table>
<tr><td colspan="4">SAMPLE INFORMATION</td></tr>
<tr><td>SAMPLE TYPE:</td><td>COMPOSITE</td><td>GRAB</td><td>SAMPLE ID:</td></tr>
<tr><td>SAMPLE MEDIA</td><td colspan="2">INDOOR AIR
SOIL VAPOR
SYSTEM PERFORMANCE
OTHER</td><td>LOCATION:
LOCATION COORDINATES:
N:
E:</td></tr>
<tr><td colspan="3">SAMPLE DURATION:</td><td>SAMPLE HEIGHT / (DEPTH):</td></tr>
<tr><td>SAMPLE CONTAINER TYPE:</td><td>SUMMA CANISTER</td><td>TEDLAR BAG</td><td>OTHER:</td></tr>
<tr><td colspan="3">FLOW VALVE ID / SERIAL NUMBER:</td><td>CANISTER SERIAL NUMBER:</td></tr>
</table>

READING	TIME	VACUUM (INCHES - Hg / PSIG)	DATE	INITIALS	COMMENTS
INITIAL VACUUM CHECK					
INITIAL FIELD VACUUM					
FINAL FIELD VACUUM					

SAMPLE START TIME:	SAMPLE STOP TIME:

NOTES AND OBSERVATIONS

MOTORIZED VEHICLE STORAGE :

MOTORIZED VEHICLE TRAFFIC:

OPERATIONS (e.g., painting, oil recovery):

CLEANERS / SOLVENTS IN USE:

MATERIAL STORAGE (e.g., paint, gasoline):

NOTICEABLE ODORS:

AUDIBLE OR NEARBY HVAC OPERATION:

OTHER:

ADDITIONAL COMMENTS:

SHIPPING METHOD: ____________	DATE SHIPPED: ____________	AIRBILL NUMBER: ____________
COC NUMBER: ____________	SIGNATURE: ____________	DATE SIGNED: ____________

TRC

GROUNDWATER SAMPLE LOG

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:	WELL DIAMETER: 2" 4" 6"	OTHER ____________
WELL MATERIAL: PVC SS IRON	GALVANIZED STEEL	OTHER ____________
SAMPLE TYPE: GW WW SW	DI LEACHATE	OTHER ____________

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:

PURGE METHOD: PUMP ____________ BAILER ____________

DEPTH TO WATER: ________ T/ PVC

DEPTH TO BOTTOM: ________ T/ PVC

PUMP INTAKE DEPTH: ________ T/ PVC

FLOW-THRU CELL VOLUME ________ LITERS

WELL VOLUME: ________ LITERS GALLONS

VOLUME REMOVED: ________ LITERS GALLONS

COLOR: ____________ ODOR: ________

TURBIDITY

NONE SLIGHT MODERATE VERY

DISPOSAL METHOD: GROUND DRUM OTHER

PH: ________ SU | CONDUCTIVITY: ________ umhos/cm

ORP: ________ mV | DO: ________ mg/L

TURBIDITY: ________ NTU

NONE SLIGHT MODERATE VERY

TEMPERATURE: ________ °C | OTHER: ____________

COLOR: ____________ | ODOR: ____________

FILTRATE (0.45 um) YES NO

FILTRATE COLOR: ________ | FILTRATE ODOR: ________

QC SAMPLE: MS/MSD DUP- ________

COMMENTS:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED — PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - _______

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED		NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	
				Y	N					Y	N
				Y	N					Y	N
				Y	N					Y	N
				Y	N					Y	N

SHIPPING METHOD: ____________	DATE SHIPPED: ____________	AIRBILL NUMBER: ____________
COC NUMBER: ____________	SIGNATURE: ____________	DATE SIGNED: ____________

WATER SAMPLE LOG

(CONTINUED FROM PREVIOUS PAGE)

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)

SIGNATURE: ______________________________ DATE SIGNED: ______________________________

LOW FLOW GROUNDWATER SAMPLING LOG

PROJECT NAME		LOCATION ID	DATE
PROJECT NUMBER		START TIME	END TIME
SAMPLE ID	SAMPLE TIME	SITE NAME/NUMBER	PAGE OF

WELL DIAMETER (INCHES) ☐ 1 ☐ 2 ☐ 4 ☐ 6 ☐ 8 ☐ OTHER ______

TUBING ID (INCHES) ☐ 1/8 ☐ 1/4 ☐ 3/8 ☐ 1/2 ☐ 5/8 ☐ OTHER ______

MEASUREMENT POINT (MP) ☐ TOP OF RISER (TOR) ☐ TOP OF CASING (TOC) ☐ OTHER ______

WELL INTEGRITY	YES	NO	N/A
CAP	___	___	___
CASING	___	___	___
LOCKED	___	___	___
COLLAR	___	___	___

INITIAL DTW (BMP)	FT	FINAL DTW (BMP)	FT	PROT. CASING STICKUP (AGS)	FT	TOC/TOR DIFFERENCE	- FT
WELL DEPTH (BMP)	FT	SCREEN LENGTH	FT	PID AMBIENT AIR	PPM	REFILL TIMER SETTING	- SEC
WATER COLUMN	FT	DRAWDOWN VOLUME (final DTW - initial DTW X well diam. squared X 0.041)	GAL	PID WELL MOUTH	PPM	DISCHARGE TIMER SETTING	- SEC
CALCULATED GAL/VOL (column X well diameter squared X 0.041)	GAL	TOTAL VOL. PURGED (mL per minute X total minutes X 0.00026 gal/mL)	GAL	DRAWDOWN/ TOTAL PURGED		PRESSURE TO PUMP	- PSI

FIELD PARAMETERS WITH PROGRAM STABILIZATION CRITERIA (AS LISTED IN THE QAPP)

TIME 3-5 Minutes	DTW (FT) 0.0-0.33 ft Drawdown	PURGE RATE (mL/min)	TEMP. (°C) (+/- 3 degrees)	SP. CONDUCTANCE (mS/cm) (+/- 3%)	pH (units) (+/- 0.1 units)	DISS. O_2 (mg/L) (+/- 10%)	TURBIDITY (ntu) (+/- 10% <10 ntu)	REDOX (mv) (+/- 10 mv)	PUMP INTAKE DEPTH (ft)	COMMENTS
	BEGIN PURGING									

FINAL STABILIZED FIELD PARAMETERS (to appropriate significant figures[SF])

TEMP.: nearest degree (ex. 10.1 = 10)
COND.: 3 SF max (ex. 3333 = 3330, 0.696 = 0.696)
pH: nearest tenth (ex. 5.53 = 5.5)
DO: nearest tenth (ex. 3.51 = 3.5)
TURB: 3 SF max, nearest tenth (6.19 = 6.2, 101 = 101)
ORP: 2 SF (44.1 = 44, 191 = 190)

EQUIPMENT DOCUMENTATION

TYPE OF PUMP	DECON FLUIDS USED	TUBING/PUMP/BLADDER MATERIALS		EQUIPMENT USED
☐ PERISTALTIC	☐ LIQUINOX	☐ SILICON TUBING	☐ S. STEEL PUMP MATERIAL	☐ WL METER ______
☐ SUBMERSIBLE	X DEIONIZED WATER	☐ TEFLON TUBING	☐ PVC PUMP MATERIAL	☐ PID ______
☐ BLADDER	☐ POTABLE WATER	☐ TEFLON LINED TUBING	☐ GEOPROBE SCREEN	☐ WQ METER ______
______	☐ NITRIC ACID	☐ HDPE TUBING	☐ TEFLON BLADDER	☐ TURB. METER ______
☐ WATTERA	☐ HEXANE	☐ LDPE TUBING	☐ OTHER ______	☐ PUMP ______
☐ OTHER ______	☐ METHANOL	☐ OTHER ______	☐ OTHER ______	☐ OTHER ______
☐ OTHER ______	X OTHER ALCONOX	☐ OTHER ______	☐ OTHER ______	☐ FILTERS NO. ___ TYPE ______

ANALYTICAL PARAMETERS

	PARAMETER	METHOD NUMBER	FIELD FILTERED	PRESERVATION METHOD	VOLUME REQUIRED	SAMPLE COLLECTED	QC COLLECTED	SAMPLE BOTTLE ID NUMBERS
☐								
☐								
☐								
☐								
☐								
☐								
☐								

PURGE OBSERVATIONS

	YES	NO	
PURGE WATER CONTAINERIZED	☐	☐	NUMBER OF GALLONS GENERATED ______
NO-PURGE METHOD UTILIZED	☐	☐	If yes, purged approximately 1 standing volume prior to sampling or ________mL for this sample location.

SKETCH/NOTES

Sampler Signature: Print Name:

Checked By: Date:

TRC		
Residential Well Sampling Log	**Project:**	**Project Number:**
	Address of Residence:	**Sample ID:**
	Homeowner's Name:	**Date:**
	Contact Number:	**Sample Time:**
		Sampler's Name:

Description of Sample Location ***(circle one)*** **:**

System Bypass Exterior Faucet Kitchen/Bath Faucet

Sketch of Sample Location	**Expansion Tank and Upstream Pipe Capacity**
	Tank Capacity (gallons) = ________
	Tank Capacity (gallons) - if not stamped on tank = (radius of tank [ft]^2*height of tank [ft])* 23.5
	Pipe Capacity (gallons) = ________
	Pipe Capacity (gallons) = (radius of pipe [ft]^2* length of pipe upstream of tank [ft])* 23.5

Required Purge Volume: __________ (gallons)	**Well Used in Past 24 Hours?** ***(circle one)***
Actual Purge Volume Prior to Sampling: _______(gallons)	Yes No Unknown
Purge Time Duration: ________ (min)	Faucet Aerator present? Yes No
Flow Rate During Sampling: ______________ (gpm)	Faucet Aerator removed prior to sampling? Yes No

Field Parameters (If Applicable)

Time										
Temp (°C)										
Conduct. (umhos/cm)										
DO (mg/L)										
pH (std units)										
ORP (millivolts)										
Turbidity (NTU)										
Volume purged (gal)										
Flow Rate (ml/min)										

Laboratory Analysis

Analytical Parameter	**Filtered? Y N**	**Preservation**	**pH Chk**	**Volume**	**# of Bottles**

Notes: (age, type [drilled/dug], well depth, well yield, water treatment system type, where applicable)

QC Sample (Field Duplicate or MS/MSD) Collected?

SOIL BORING LOG

TRC	Project Name:		Boring ID:
	Project Location:		Page No.
	Project No.:	Client:	of:
Boring Location:	Refusal Depth:	Total Depth:	Bore Hole ID/OD:
Weather:	Soil Drilled:	Method:	Casing Size:
Subcontractor:		Protection Level:	Sampler:
Driller:	Date Started:	Date Completed:	Sampler ID/OD:
Rig Type/Model:	Logged By:	Checked By:	Latitude:
Reference Elevation:	Water Level:	Time:	Longitude:

Sample Information				Monitoring				Sample Description and Classification	USCS Group Symbol	Remarks
Depth (feet bgs) 0.0	Sample Number	Penetration/ Recovery (feet)	PID Reading (ppm)							

NOTES:

10 Maxwell Drive, Suite 200
Clifton Park, NY 12065

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Site Name: ______ Site Code: ______ Operable Unit: ______

Building Code: ______ Building Name: ______

Address: ______ Apt/Suite No: ______

City: ______ State: ______ Zip: ______ County: ______

Contact Information

Preparer's Name: ______ Phone No: ______

Preparer's Affiliation: ______ Company Code: ______

Purpose of Investigation: ______ Date of Inspection: ______

Contact Name: ______ Affiliation: ______

Phone No: ______ Alt. Phone No: ______ Email: ______

Number of Occupants (total): ______ Number of Children: ______

☐ Occupant Interviewed? ☐ Owner Occupied? ☐ Owner Interviewed?

Owner Name (if different): ______ Owner Phone: ______

Owner Mailing Address: ______

Building Details

Bldg Type (Res/Com/Ind/Mixed): ______ Bldg Size (S/M/L): ______

If Commercial or Industrial Facility, Select Operations: ______

If Residential Select Structure Type: ______

Number of Floors: ______ Approx. Year Construction: ______ ☐ Building Insulated? ☐ Attached Garage?

Describe Overall Building 'Tightness' and Airflows(e.g., results of smoke tests): ______

Foundation Description

Foundation Type: ______ Foundation Depth (bgs): ______ Unit: FEET

Foundation Floor Material: ______ Foundation Floor Thickness: ______

Foundation Wall Material: ______ Foundation Wall Thickness: ______ Unit: INCHES

☐ Floor penetrations? Describe Floor Penetrations: ______

☐ Wall penetrations? Describe Wall Penetrations: ______

Basement is: ______ Basement is: ______ ☐ Sumps/Drains? Water In Sump?: ______

Describe Foundation Condition (cracks, seepage, etc.) : ______

☐ Radon Mitigation System Installed? ☐ VOC Mitigation System Installed? ☐ Mitigation System On?

Heating / Cooling / Ventilation Systems

Heating System: ______ Heat Fuel Type: ______ ☐ Central A/C Present?

Vented Appliances

Water Heater Fuel Type: ______ Clothes Dryer Fuel Type: ______

Water Htr Vent Location: ______ Dryer Vent Location: ______

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

PRODUCT INVENTORY

Building Name: ______________________ Bldg Code: ______________ Date: ______________

Bldg Address: ______________________________________ Apt/Suite No: ______________

Bldg City/State/Zip: ______________________________________

Make and Model of PID: ______________________ Date of Calibration: ______________

Location	Product Name/Description	Size (oz)	Condition *	Chemical Ingredients	PID Reading	COC Y/N?
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐

* Describe the condition of the product containers as **Unopened (UO)**, **Used (U)**, or **Deteriorated (D)**

** Photographs of the **front and back** of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

Product Inventory Complete? ☐ Were there any elevated PID readings taken on site? ☐ ☐ Products with COC?

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Site Name: ______________________ Site Code: __________ Operable Unit: ________

Building Code: ______________________ Building Name: ______________________

Address: ______________________ Apt/Suite No: __________

City: ______________________ State: ______ Zip: ________ County: __________

Factors Affecting Indoor Air Quailty

Frequency Basement/Lowest Level is Occupied?: [ ] Floor Material: [ ]

☐ Inhabited? ☐ HVAC System On? ☐ Bathroom Exhaust Fan? ☐ Kitchen Exhaust Fan?

Alternate Heat Source: [ ] ☐ Is there smoking in the building?

☐ Air Fresheners? Description/Location of Air Freshener: ______________________

☐ Cleaning Products Used Recently?: Description of Cleaning Products: ______________________

☐ Cosmetic Products Used Recently?: Description of Cosmetic Products: ______________________

☐ New Carpet or Furniture? Location of New Carpet/Furniture: ______________________

☐ Recent Dry Cleaning? Location of Recently Dry Cleaned Fabrics: ______________________

☐ Recent Painting/Staining? Location of New Painting: ______________________

☐ Solvent or Chemical Odors? Describe Odors (if any): ______________________

☐ Do Any Occupants Use Solvents At Work? If So, List Solvents Used: ______________________

☐ Recent Pesticide/Rodenticide? Description of Last Use: ______________________

Describe Any Household Activities (chemical use,/storage, unvented appliances, hobbies, etc.) That May Affect Indoor Air Quality:

☐ Any Prior Testing For Radon? If So, When?: ______________________

☐ Any Prior Testing For VOCs? If So, When?: ______________________

Sampling Conditions

Weather Conditions: [ ] Outdoor Temperature: [ ] °F

Current Building Use: [ ] Barometric Pressure: [ ] in(hg)

Product Inventory Complete? [ ] ☐ Building Questionnaire Completed?

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Building Code: ____________________ Address: ____

Sampling Information

Sampler Name(s): ______________________________ Sampler Company Code: ________________

Sample Collection Date: [ ] Date Samples Sent To Lab: ________________

Sample Chain of Custody Number: ______________________ Outdoor Air Sample Location ID: ____________

SUMMA Canister Information

Sample ID:					
Location Code:					
Location Type:					
Canister ID:					
Regulator ID:					
Matrix:					
Sampling Method:					

Sampling Area Info

Slab Thickness (inches):					
Sub-Slab Material:					
Sub-Slab Moisture:					
Seal Type:					
Seal Adequate?:	☐	☐	☐	☐	☐

Sample Times and Vacuum Readings

Sample Start Date/Time:					
Vacuum Gauge Start:					
Sample End Date/Time:					
Vacuum Gauge End:					
Sample Duration (hrs):					
Vacuum Gauge Unit:					

Sample QA / QC Readings

Vapor Port Purge:	☐	☐	☐	☐	☐
Purge PID Reading:					
Purge PID Unit:					
Tracer Test Pass:	☐	☐	☐	☐	☐

Sample start and end times should be entered using the following format: MM/DD/YYYY HH:MM

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

LOWEST BUILDING LEVEL LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the lowest building level .
The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sket(
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or F	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

FIRST FLOOR BUILDING LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the first floor of the building.
The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sket
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or **F**	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

OUTDOOR PLOT LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the outdoor plot of the building as well as the surrounding area. The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sket(
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or **F**	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

TRC Surface Water/Sediment Sample Log	Project:	Project No.:	Date/Time:	Sheet 1 of 1
	Contractor Personnel:		TRC Personnel:	

Sample No.:	**Sample Location:**
Depth/Interval Sampled:	**Sample Type: (circle)** Grab Composite Both
Field Screening Information:	**Media: (circle)** Other ___________ Sediment Surface Water **Water Depth:**
Other Field Observations:	**Sample Description/Observations:**

SAMPLE COLLECTION EQUIPMENT

Hand Auger	☐	Dip Sampler	☐
Core Sampler	☐	Trowel	☐
Spatula/Spoon	☐	Dredge Sampler	☐
Bowl (stainless)	☐	Kemmerer	☐
En-Core®	☐	Extension Rods	☐
Tube Auger	☐	Van Dorn Bottle	☐
Direct	☐	Spade	☐
Ponar Grab	☐	Shovel	☐
Bucket Auger	☐	Terra Core™	☐
Peristaltic Pump	☐	Scoop	☐
Macro-Core®	☐	Vibracore	☐
Other	☐	Split-spoon	☐

Analytical Parameters	Preservation Method	Volume/Container	Time of Collection	Sample ID

Signed: ______________________________

Test Pit Log

Test Pit Log	Project Name/Number:	Test Pit Number: Sheet___ of ___
	Location:	Date/Time
Equipment Used (e.g., reach/capacity):	Contractor Personnel:	TRC Personnel:
Total Depth:	Contractor Used:	Top of Pit Elevation:
Depth to Ground Water:	Weather:	

Depth	Sample Number	Stratigraphic Description	REMARKS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

TEST PIT PLAN

North

Vol = ____ cu. yd.

PROPORTIONS

BURMISTER USED

Trace (TR)	0-10%
Little (LI)	10-20%
Some (SO)	20-35%
And	35-50%

USCS USED

Trace (TR)	<5%
Few	5-10%
Little (LI)	15-25%
Some (SO)	30-45%
Mostly (MO)	>50%

GRAIN SIZE (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
e. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Comments: ______________________________

____

____

____

____

Rev: October 2014

WATER AND PRODUCT LEVEL MONITORING FORM

Technician: ________________ **Job #/Task #:** ____________________ **Date:** ________________

Site # ________________ **Project Manager** ____________________ **Page** ______ **of** _______

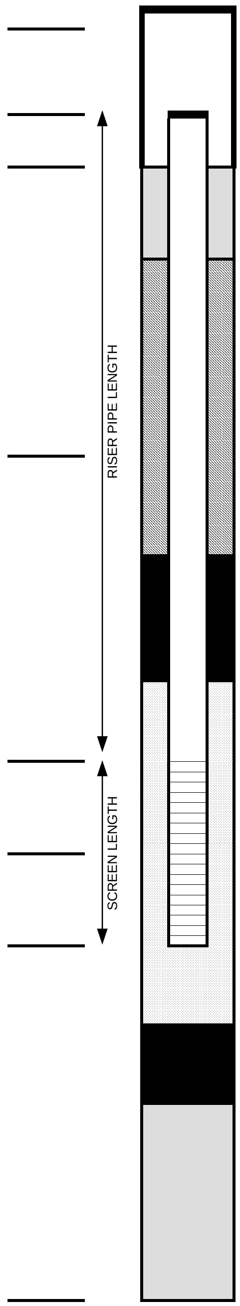
Well #	TOC	Time Gauged	Total Depth (feet)	Depth to Water (feet)	Depth to Product (feet)	Product Thickness (feet)	Time Sampled	Misc. Well Notes

FIELD DATA COMPLETE	QA/QC	COC	WELL BOX CONDITION SHEETS
MANIFEST	DRUM INVENTORY	TRAFFIC CONTROL	

WELL CONSTRUCTION DIAGRAM (FLUSH-MOUNT)

PROJ. NAME:			WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:	CHECKED BY:	

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



0.0 GROUND SURFACE

TOP OF CASING

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________

PIPE SCHEDULE: ____________

PIPE JOINTS: ____________

SCREEN TYPE: ____________

SCR. SLOT SIZE: ______

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________

TIME DEVELOPING: ____ HOURS

WATER REMOVED: ____ GALLONS

WATER ADDED: ____ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________

COLOR BEFORE: ____________

CLARITY AFTER: ____________

COLOR AFTER: ____________

ODOR (IF PRESENT): ____________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

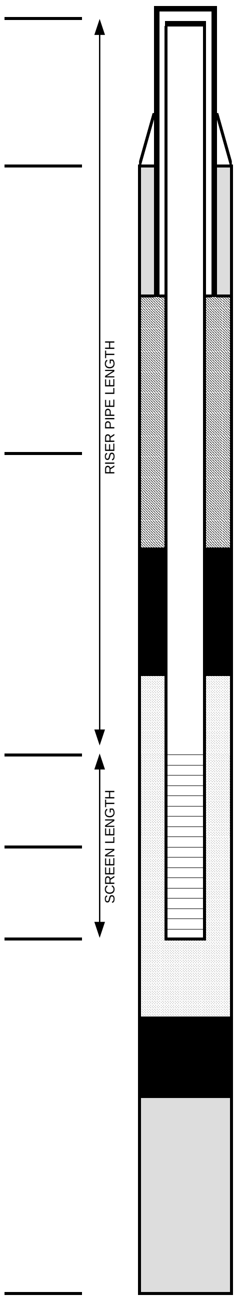
LOCK KEY NUMBER: ____________

TRC

WELL CONSTRUCTION DIAGRAM (ABOVE-GRADE)

PROJ. NAME:		WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:	CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



TOP OF CASING

0.0 GROUND SURFACE

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________________

PIPE SCHEDULE: ____________________

PIPE JOINTS: ____________________

SCREEN TYPE: ____________________

SCR. SLOT SIZE: ________

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________________

TIME DEVELOPING: ______ HOURS

WATER REMOVED: ______ GALLONS

WATER ADDED: ______ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________________

COLOR BEFORE: ____________________

CLARITY AFTER: ____________________

COLOR AFTER: ____________________

ODOR (IF PRESENT): ____________________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

LOCK KEY NUMBER: ____________

FIGURE 3

WELL DECOMMISSIONING RECORD

Site Name:	Well I.D.:
Site Location:	Driller:
Drilling Co.:	Inspector:
	Date:

DECOMMISSIONING DATA
(Fill in all that apply)

<u>OVERDRILLING</u>

Interval Drilled	
Drilling Method(s)	
Borehole Dia. (in.)	
Temporary Casing Installed? (y/n)	
Depth temporary casing installed	
Casing type/dia. (in.)	
Method of installing	

<u>CASING PULLING</u>

Method employed	
Casing retrieved (feet)	
Casing type/dia. (in)	

<u>CASING PERFORATING</u>

Equipment used	
Number of perforations/foot	
Size of perforations	
Interval perforated	

<u>GROUTING</u>

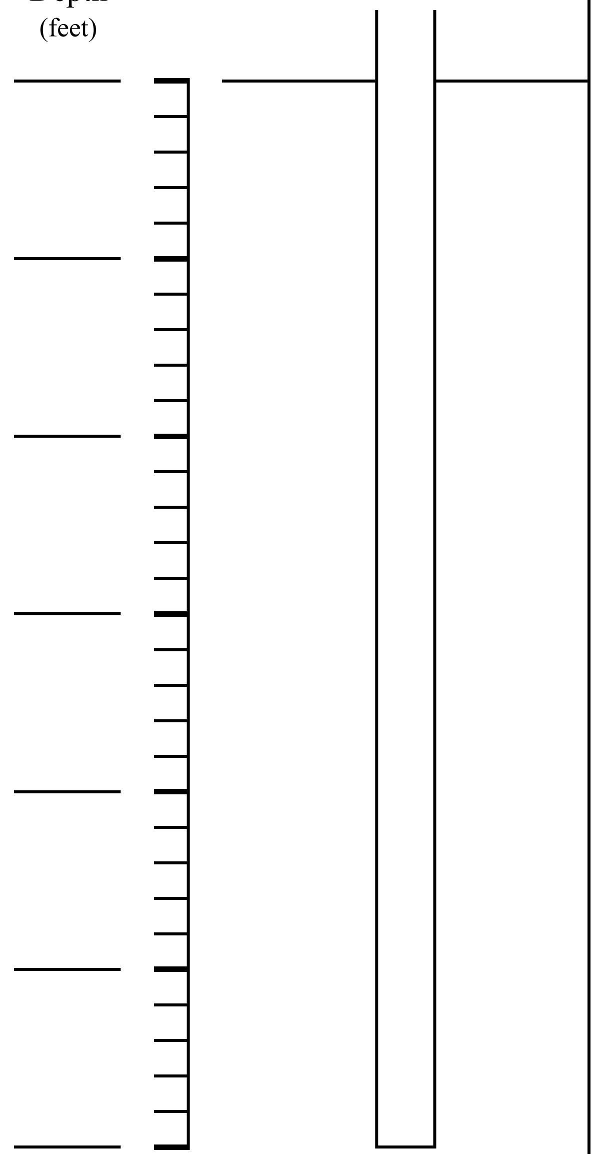
Interval grouted (FBLS)	
# of batches prepared	

<u>For each batch record:</u>

Quantity of water used (gal.)	
Quantity of cement used (lbs.)	
Cement type	
Quantity of bentonite used (lbs.)	
Quantity of calcium chloride used (lbs.)	
Volume of grout prepared (gal.)	
Volume of grout used (gal.)	

WELL SCHEMATIC*

Depth
(feet)



COMMENTS:

* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

Drilling Contractor

Department Representative

TRC
Results you can rely on

Well Development Form

Project: **Project No.:** **Date/Time:** **Sheet ___ of ___**

TRC Personnel:

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) _______ ft.

Riser Stick-up (from ground) _______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ _____

WELL MATERIAL ☐ PVC ☐ SS ☐ ___

Well Depth ____ ft. ☐ top of riser ☐ top of casing ☐ _________ ☐ measured ☐ historical

Water Depth ____ ft.

Height of Water Column ____ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

[Vol. = r^2 h(0.163)] ______ Total gallons purged

FIELD WATER QUALITY MEASUREMENTS

Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									
Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									

EQUIPMENT USED:

NOTES/COMMENTS:

Signed:______________________________

New Yor State Department of Environmental Conservation
Farrand Controls Site, Valhalla, Westchester County, New York
NYSDEC Site No. 360046, Work Assignment No. D009812-30

INSPECTOR: _______________
DATE/TIME: _______________
WELL ID: _______________

Monitoring Well Inspection Form

	YES	NO
WELL VISIBLE? (If not, provided directions below)		
WELL ID VISIBLE?		
WELL LOCATTIONS MATCH SITE MAP? (If not, sketch actual location on back)		

WELL I.D. AS IT APPEARS ON PROTECTIVE CASING OR WELL: ....

	YES	NO
SURFACE SEAL PRESENT?		
SURFACE SEAL COMPETENT? (if cracked, heaved, etc., describe below)		
PROTECTIVE CASING IN GOOD CONDITION? (If damaged, describe below)		

HEADSPACE READING (ppm) AND INSTRUMENT USED .... _______________
TYPE OF PROTECTIVE CASING AND HEIGHT OF STICKUP IN FEET (If applicable) .... _______________
PROTECTIVE CASING MATERIAL TYPE: .... _______________
MEASURE PROTECTIVE CASING INSIDE DIAMETER (Inches): ....

	YES	NO
LOCK PRESENT?		
LOCK FUNCTIONAL?		
DID YOU REPLACE THE LOCK?		
IS THER EVIDENCE THAT THE WELL IS DOUBLE-CASED? (If yes, describe below)		
WELL MEASURING POINT VISIBLE?		

WELL DEPTH FROM MEASURING POINT (Feet): .... _______________
DEPTH OF WATER FROM MEASURING POINT (Feet):.. _______________
WELL DIAMETER (Inches): .... _______________
WELL CASING MATERIAL: .... _______________
PHYSICAL CONDITION OF VISIBLE WELL CASING: .... _______________
ATTACH ID MARKER (if well ID is confirmed) and IDENTIFY MARKER TYPE .... _______________
PROXIMITY TO UNDERGROUND OR OVERHEAD UTILITIES .... _______________

DESCRIBE ACCESS TO WELL: (Include accessibility to truck mounted rig, natural obstructions, overhead power lines, proximity to permanent structures, etc.); ADD SKETCH OF LOCATION ON BACK, IF NECESSARY.

DESCRIBE WELL SETTING (For example, located in a field, in a playground, on pavement, in a garden, etc.) AND ASSESS THE TYPE OF RESTORATION REQUIRED.

IDENTIFY ANY NEARBY POTENTIAL SOURCES OF CONTAMINATION, IF PRESENT (e.g. Gas station, salt pile, etc.):

REMARKS:

GENERIC QUALITY ASSURANCE PROJECT PLAN

STANDBY ENGINEERING SERVICES
CONTRACT NO: D009812

Prepared for:

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, New York 12233

Prepared by:

TRC Engineers, Inc.
1430 Broadway
New York, New York 10018

JULY 2020

RECORD OF REVISIONS

Revision No.	Revision Date	Summary of Revisions	Modified by:
0	07/02/2020	New Document	J. King

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SECTION PAGE

APPENDICES

1.0 INTRODUCTION

This Generic Quality Assurance Project Plan (QAPP) has been developed for use on work assignments issued to TRC Engineers, Inc. (TRC) under New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation (DER), Standby Engineering Services Contract No. D009812. Compliance with this Generic QAPP, and associated documents, is required for all TRC personnel working on NYSDEC project sites and/or conducting NYSDEC project field work. This Generic QAPP has been prepared to meet the requirements specified in the contract and includes the following:

- Objectives of the QAPP (Section 1.1)
- Responsibilities of the Consultant (Section 1.3)
- Sampling and Custody Procedures (Sections 3.0 through 7.0 and Appendix D)
- Analytical Procedures (Section 4.0)
- Field and Laboratory Quality Control Checklist and Frequency Procedures (Sections 4.0 and 6.0)
- Preventative Maintenance Procedures (Section 7.0 and Appendix F)
- Quality Assurance Performance and System Audit Procedures (Sections 8.0 and 9.0)
- Corrective Action Procedures (Section 10.0)
- Additional information necessary to comply with the most current approved guidelines (Sections 2.0 through 10.0 and Appendices A and F)

1.1 Objective and Scope of the Generic QAPP

This QAPP was developed to outline the procedures and guidelines which TRC and its subcontractors will follow to ensure the reliable collection and handling of environmental samples and analytical data. While the full scope of environmental investigations at NYSDEC sites is not presently known, this QAPP is intended to provide the information necessary to establish general quality assurance (QA) and quality control (QC) protocols for investigations which may be conducted. It is the responsibility of TRC to adhere to the procedures and guidelines outlined herein to provide the most accurate data to the NYSDEC.

This QAPP serves as a controlling mechanism during field sampling, laboratory analysis, and data validation to ensure that data collected are valid, reliable, and legally defensible. The QAPP outlines the organization, objectives, and the QA/QC activities which will ensure achievement of desired data goals.

This QAPP provides general information and references standard operating procedures (SOPs) applicable to the sampling program detailed in each site-specific work plan. This information includes definitions and generic goals for data quality and required types and quantities of QC samples. These procedures address field documentation; sample handling, custody, and shipping; instrument calibration and maintenance; auditing; data reduction, validation, and reporting; corrective action requirements; and QC reporting specific to the analyses performed by the contracted laboratory. The field activity specific SOPs can be found in TRC's Generic Field Activities Plan (FAP).

The data generated from the field investigations may be used to determine the nature, extent, and source(s) of contamination at the site, prepare a qualitative human health risk and environmental assessment/site hazard assessment, and develop a cost-effective, environmentally sound, long-term remediation plan consistent with the planned use of the site. The data may also be utilized to monitor for the health and safety of workers at the site and potential off-site receptors.

If any of the collection procedures, sample analysis or sample matrices are modified for a specific site investigation, detailed information regarding the changes and rationale for the change will be provided in a site-specific QAPP addendum and/or in the site-specific work plan.

1.2 Generic QAPP Review and Amendments

This QAPP will be periodically reviewed for its accuracy and applicability to TRC, the NYSDEC, and their activities on project sites. As required, this QAPP will be updated and/or revised to incorporate specific analytical methodologies, modifications, or test procedures used for future environmental investigations. The individual responsible for reviewing the Generic QAPP will be the TRC Quality Assurance Officer (QAO) who is a quality professional and is aware of environmental and laboratory issues and has the authority to implement revisions/changes to the Generic QAPP, where necessary.

The Generic QAPP will undergo a complete review (and/or amendment as appropriate) at the following frequencies:

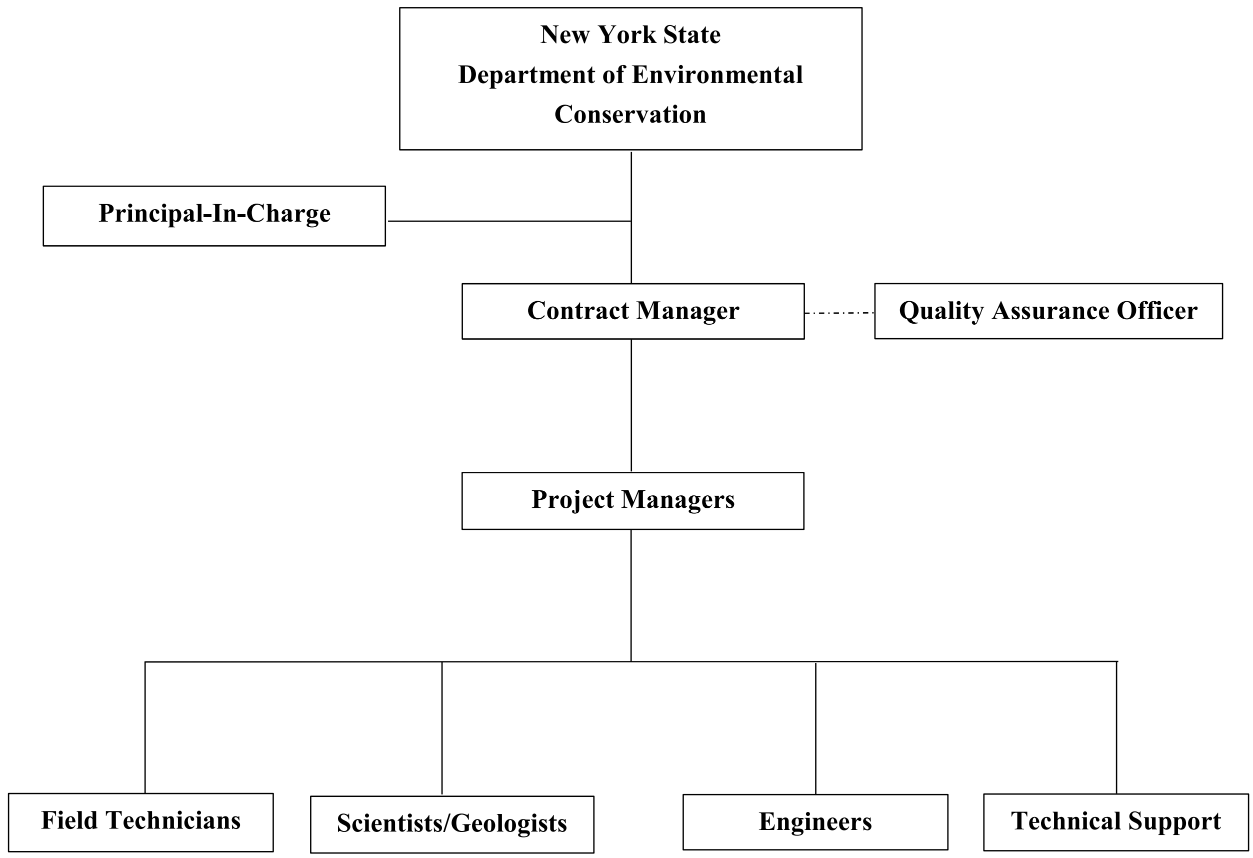
- Annually
- Change in applicable regulations, standards, guidance, policies, etc.
- Change in TRC SOPs
- Upon NYSDEC request

Generic QAPP modifications will be made within 60 calendar days after discovery, observation, or event requiring the review. If revisions and/or changes are made to the Generic QAPP, such revisions will be described in the **Record of Revisions** and provided to the NYSDEC for review and approval. Implementation of the new or modified procedures will be initiated immediately upon NYSDEC approval.

1.3 Consultant Responsibilities

TRC's organizational structure for this contract is presented on the Organizational Chart which follows this page. Project Managers and key staff (i.e., Field Technicians, Scientists/Geologists, Engineers, and

Organizational Chart
Standby Engineering Services Contract No. D009812



Technical Support) report directly to the Contract Manager for direction in connection with contract and project-related tasks. The Contract Manager, QAO, Project Managers, and majority of key staff either report to the Principal-in-Charge, to a direct report of the Principal-in-Charge, or to a subordinate of one of the Principal-in-Charge's direct reports. The Principal-in-Charge provides support directly to the Contract Manager and maintains overall corporate responsibility for ensuring all required resources are made available for the contract, that TRC's performance is of the highest quality, and that projects are properly executed and successfully completed within schedule and budget. Primary lines of communication are maintained between Project Managers and key staff. Project Managers have day-to-day decision-making authority for technical and administrative matters regarding projects. The QAO reports directly to the Principal-in-Charge but communicates directly with the Contract Manager and Project Managers on project-specific issues. The QAO has unquestionable authority to override the Project Manager's decisions on QA/QC matters and procedures. A summary of the QA/QC responsibilities for the roles represented on the organizational chart are presented below.

The following is a list of responsibilities for each of the above identified roles. Some personnel my at times fill more than one role depending on the individual assignment's tasks and the scope of the projects.

Principal-In-Charge:

- Staff and resource allocation
- Monitor and ensure performance is of the highest quality
- Provide management assistance
- Review work products

Contract Manager:

- Contract administration and compliance
- Ensure projects are completed in accordance with technical and administrative requirements
- Ensure staff and resource availability
- Assign project teams in consultation with the Principal-in-Charge
- Monitor and ensure Project Manager/Project Team performance
- Review work products
- Subcontractor review and approval

Quality Assurance Officer:

- Preparation and routine updating, as needed, of the Generic QAPP and FAP
- Conduct laboratory audits

- Conduct field audits
- Provide training regarding monitoring, sampling and QA procedures
- Review chain-of-custody forms and other field forms for accuracy and completeness
- Perform in-house data validation and supervises subcontractor data validation
- Prepare DUSRs
- Oversee inventory and maintenance of field equipment
- Interfaces on a routine basis with the Project Managers

Project Managers:

- Coordinate project activities with the NYSDEC Project Managers
- Manage day-to-day project activities
- Ensure proper implementation of the FAP and QAPP
- Continuously monitor progress with respect to schedule and budget
- Review work products
- Manage and monitor the work of subcontractors

Key Staff:

- Maintain knowledge of QA/QC policies
- Execute work as per QA/QC policies
- Collect data in accordance with approved plans using a wide range of field investigation techniques
- Review, analyze and evaluate data
- Prepare work products

2.0 DATA QUALITY

The type of data needed to meet the project quality objectives (PQOs) includes the required contaminants of concern, concentration levels, media to be sampled, analysis type, and appropriate sampling techniques. The quantity of data needed to meet the PQOs includes the number of samples for each analytical parameter of each media and a definition of the project boundaries. This information will be detailed in site-specific work plans. The quality of data needed to achieve the PQOs includes the necessary data quality indicators (precision, accuracy, representativeness, comparability, completeness, and sensitivity) required of each analytical parameter used for each media sampled. The limits set on each of these items are referred to as measurement performance criteria and define the quality of data generated. Measurement performance criteria have been established for each parameter in order to ensure the data are sound, highly defensible, and with low enough reporting limits to meet human health or ecological risk-based standards when required.

Laboratories will report reporting limits as low as technically possible and will estimate values detected below the quantitation limit. Data obtained during the site investigations will be compared to specific Standards, Criteria, and Guidelines (SCGs). The SCGs that will generally be utilized for screening purposes are provided below.

Standards, Criteria, and Guidelines

Matrix	SCG
Groundwater Surface water	NYSDEC 6 New York Codes, Rules and Regulations (NYCRR), Parts 700-706 and 750-757. NYSDEC Division of Water Technical and Operational Guidance Series (1.1.1) - Ambient Water Quality Standards and Guidance Values, dated June 1998, addendum April 2000 and June 2004. Guidelines for Sampling and Analysis of PFAS, NYSDEC Part 375 Remedial Programs, January 2020.
Soil Sediment	NYSDEC 6 NYCRR, Subpart 375-6 Remedial Program Soil Cleanup Objectives, effective December 14, 2006. NYSDEC Commissioner Policy CP-51 on Soil Cleanup Guidance, effective December 3, 2010. NYSDEC Screening and Assessment of Contaminated Sediment, June 24, 2014.

Standards, Criteria, and Guidelines

Matrix	SCG
	Guidelines for Sampling and Analysis of PFAS, NYSDEC Part 375 Remedial Programs, January 2020.
Soil Vapor Indoor Air Ambient Air Sub-slab Vapor Perimeter Air	NYSDEC DAR-1, Guidelines for the Control of Toxic Ambient Air Contaminants, dated November 1997* NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York dated October 2006, addendum May 2017. NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation (DER-10), Appendices 1A and 1B, New York State Department of Health (NYSDOH) Generic CAMP and Fugitive Dust and Particulate Monitoring, respectively.
Waste	NYSDEC 6 NYCRR Parts 360, 364, 370, 371, 372, 375 and 376 and Subparts 373-2, 373-3, 373-4, 374-1, and 374-2. United States Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Part 761.

* Including Complete and Hazardous Air Pollutant Listings, Annual Guideline Concentrations (AGCs), SCGs and Air Quality Standards for the DAR-1 Software Program.

Final selection of SCGs for site remediation and development will be based on the intended use of the property, potential receptors and potential contaminant migration pathways. These SCGs may also consider the USEPA Regional Screening Levels.

The proposed analytical methodologies (Section 4.1) will be able to achieve the PQOs. That is, the analytical methodologies are generally capable of detecting the target analytes below the applicable SCG. These methods provide the highest level of data quality and can be used for purposes of risk assessment, evaluation of remedial systems and verification that cleanup standards have been met. However, in order to ensure that the analytical methodologies can achieve the data quality objectives, measurement performance criteria have been set for the analytical measurements in terms of accuracy, precision, representativeness, completeness, sensitivity, and comparability.

The measurement performance criteria for each parameter are further defined in this section. The analytical methods which will be used for most investigations are summarized in **Appendix A**. Laboratory SOPs are not included in this Generic QAPP but will be available upon request from the laboratory selected to perform the analyses. The laboratory will be NYSDOH Environmental Laboratory Approval Program (ELAP) certified for the required analyses.

2.1 Precision

Precision is the agreement among a set of replicate measurements without consideration of the “true” or accurate value: i.e., variability between measurements of the same material for the same analyte. Precision is measured in a variety of ways including statistically, such as calculating variance or standard deviation.

Field precision is assessed through the collection and measurement of field duplicates (one extra sample in addition to the original field sample). In general, field duplicates will be collected at a frequency of one per 20 investigative samples per matrix per analytical parameter. Precision will be measured through the calculation of relative percent difference (RPD). The resulting information will be used to assess sample homogeneity, spatial variability at the site, sample collection reproducibility, and analytical variability. In general, field duplicate RPDs must be $\leq$30 for aqueous and air samples and $\leq$50 for solid samples. Field precision will be improved by following SOPs, utilizing experienced/trained sampling crews, and conducting field audits.

Precision in the laboratory is assessed through the calculation of RPD for laboratory duplicate samples (two samples from the same container). Laboratory precision measures both sample preparation and analysis reproducibility. For the organic analyses, laboratory precision will be assessed through the analysis of matrix spike/matrix spike duplicate (MS/MSD) samples and/or field duplicates. MS/MSD samples will be performed at a frequency of one per 20 investigative samples per matrix. For the inorganic analyses, laboratory precision will be assessed through the analysis of laboratory duplicate samples and/or field duplicates. Laboratory duplicate samples will be performed at a frequency of one per 20 investigative samples per matrix.

2.2 Accuracy

Accuracy is the closeness of agreement between an observed value and an accepted reference value. The difference between the observed value and the reference value includes components of both systematic error (bias) and random error.

Accuracy in the field is assessed through the adherence to all field instrument calibration procedures, sample handling, preservation, and holding time requirements. Accuracy will also be evaluated through the use of trip blanks, equipment blanks, and cooler temperature blanks.

Equipment blanks will be collected by passing laboratory-supplied deionized water over and/or through the respective sampling equipment utilized during each sampling effort. One equipment blank will be collected for each type of non-dedicated field equipment used during each sampling event. One equipment blanks will be collected for each target parameter at a frequency of one per day. Trip blanks will be submitted with each cooler which includes aqueous volatile organic compound (VOC) samples. Trip blank samples will be analyzed for the same VOCs for which the associated media are being analyzed. The equipment and trip blanks will indicate any adverse effects of sample contamination from an outside source (i.e., sample collection) and could result in a positive or negative bias. The bias will be minimized by following standardized SOPs for equipment decontamination, utilizing an experienced/trained sampling crew, conducting field audits, and ensuring the purity of all chemicals.

Laboratories assess the overall accuracy of their instruments and analytical methods (independent of sample or matrix effects) through the measurement of "standards", materials of accepted reference value. Accuracy will vary from analysis to analysis because of individual sample and matrix effects. In an individual analysis, accuracy will be measured in terms of method blank results, the percent recovery (%R) of surrogate or internal standard compounds in organic analyses, or %R of spiked compounds in MSs and/or MSDs, and/or laboratory control samples (LCSs). This gives an indication of expected recovery for analytes tending to behave chemically like the spiked or surrogate compounds and provides a measure of bias for the parameter of interest. The laboratory method blanks will indicate any adverse effects of sample contamination from an outside source (i.e., sample preparation or sample analysis) and could result in a positive or negative bias.

The frequency of method blanks, surrogates or internal standards, MSs, MSDs, and LCSs are defined in the analytical methods and laboratory SOPs. Laboratory accuracy will be improved by following the USEPA methods and laboratory SOPs, which include detailed requirements for each analysis, utilizing experienced/trained laboratory personnel, ensuring the purity of all chemicals, and conducting laboratory audits.

2.3 Representativeness

Representativeness is a qualitative parameter which expresses the degree to which the data and sampling design accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary. The proper design of the sampling program and the laboratory quality control program ensures that the sampling is representative in the quality assurance program.

Representativeness will be satisfied by ensuring that the sampling plan and sampling methods are followed, and that proper sampling, sample handling, and sample preservation techniques are used. Representativeness may also be assessed by the use of field duplicate samples. By definition, field duplicate samples are collected so they are equally representative of a given point in space and time. In this way, they provide both precision and representativeness information. As stated previously, field duplicate samples will be collected at a frequency of one per 20 investigative samples per matrix per analytical parameter which the exception of general chemistry requirements (i.e. percent solids, pH, corrosivity, etc.).

In general, representativeness in the field will be maximized by the following methods: proper sample homogenization procedures, proper sample preservation procedures, utilizing experienced/trained sampling crews, and conducting field audits.

Representativeness in the laboratory is ensured by using the proper analytical procedures and appropriate methods, and by meeting sample holding times. Following the detailed requirements outlined in the USEPA methods and the laboratory SOPs will maximize the representativeness of the laboratory data.

2.4 Comparability

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared to another.

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the sampling plan and QAPP are followed, sampling methods are followed, and that proper sampling and preservation techniques are used.

Comparability is dependent on the use of USEPA methods and approved laboratory SOPs, and the reporting of data in standardized units.

2.5 Sensitivity

Sensitivity is the ability of the instrument or method to detect the contaminants of concern at the level of interest. The reporting limits are generally below the SCGs, as defined by the limitations of the method. In almost all cases, USEPA methods were selected to achieve the SCGs. Several analytes may not be able to achieve the SCGs due to the limitations of the method.

Laboratories will need to adjust all reporting limits based on dilutions, sample sizes, extract/digestate volumes, percent solids and cleanup procedures. Sensitivity will be maximized by following the USEPA methods or laboratory SOPs utilizing experienced/trained laboratory personnel and conducting laboratory audits.

2.6 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. “Normal conditions” are defined as the conditions expected if the sampling plan was implemented as planned.

Field completeness is a measure of the amount of (1) valid measurements obtained from all the measurements taken in the project and (2) valid samples collected. The field completeness objective is greater than 90 percent. This allows for the potential loss of samples due to sampling problems or bottle breakage during transport.

Laboratory completeness is a measure of the amount of valid measurements obtained from all valid samples submitted to the laboratory. The laboratory completeness objective is greater than 95 percent. This allows for the potential loss of samples impossible to analyze due to unforeseen interferences and rejected data following data validation.

3.0 SAMPLING DESIGN

The following presents a general discussion of the sampling that may be conducted during field investigations for work assignments. SOPs for typical field investigation activities are provided in the Generic FAP.

- Soil Vapor - Soil vapor samples will be collected during soil vapor surveys or sub-slab sampling programs to locate/confirm the source and extent of contamination.
- Surface Soil - Surface soil samples will be collected to determine the nature and extent of surface soil contamination.
- Subsurface Soil - Subsurface soil samples will be collected during construction of monitoring wells and borings, test pits or at direct-push probe locations to determine the nature and extent of on-site subsurface soil contamination.
- Sediment/Sludge - Sediment and sludge samples will be collected from dry wells, storm drainage systems and/or wastewater disposal/sanitary systems located on-site to determine if collection/disposal systems are a source of contamination.
- Wastewater/Drainage Water - Waste water and drainage water samples will be collected from dry wells and/or wastewater disposal/sanitary systems located on-site to determine if these wells/systems are a source of contamination.
- Storm Water - Storm water samples will be collected from catch basins and storm drains located on-site to determine if the storm water system has been contaminated or is a source of contamination.
- Groundwater - Groundwater samples will be obtained from monitoring wells, direct-push probes or hydropunch sampling devices, which will be installed as part of the site investigation, or from monitoring wells, which were installed previously at the site, to determine if disposal of waste material on-site has impacted groundwater.
- Water Supply - Water supply samples will be collected from private water supply systems to determine if these systems are impacted by on-site (or off-site) contamination.
- Air - Ambient air samples will be collected on-site, particularly in structures, to determine potential exposure to vapor emissions as a result of on-site waste disposal or contaminated soil and/or groundwater underlying the site.
- Asbestos - Bulk suspect asbestos-containing material (ACM) samples of building materials will be collected from the interior and exterior of site buildings and structures to determine the locations, quantities, friability and condition of any ACM present.
- Paint Chip – Paint chip samples will be collected from the interior and exterior of site buildings and structures to determine if lead based paint is present.

- Wipes – Wipe samples will be collected from the interior and exterior surfaces of site buildings and structures to evaluate surface contamination and/or the effectiveness of decontamination activities as needed.

Environmental samples will be collected from different locations as part of the field investigation. As noted above, these may include but are not limited to: groundwater, wastewater, storm/drainage water, sediment/sludge, subsurface soil, surface soil, soil vapor and ambient air, concrete chips and/or cores, wipes. Sample locations will consist of monitoring wells, water supply wells, dry wells, wastewater disposal/sanitary systems, direct push probe locations, hydropunch locations, storm water drainage systems, soil borings, surface soils, test pits, soil vapor points and ambient air. Actual locations will be determined on a site-specific basis.

There will be several steps taken after the transfer of the soil or water sample into the sample container that are necessary to properly complete collection activities. Once the sample is transferred into the appropriate container, the container will be capped and, if necessary, the outside of the container will be wiped with a clean paper towel to remove excess sampling material. The container will not be submerged in water to clean it. Rather, if necessary, a clean paper towel moistened with distilled/deionized water will be used.

When collecting soil samples, an attempt will be made to maintain sample integrity by preserving its physical form and chemical composition to as great an extent as possible. An appropriate sampling device (i.e., decontaminated or dedicated equipment) will be utilized to transfer the sample into the sample container. Samples will contain a representative mix of the matrix from which it was collected.

The materials involved in groundwater sampling are critical to the collection of high-quality monitoring information, particularly where the analyses of volatile, pH sensitive or reduced chemical constituents are of interest. The bailers and pump parts will consist of polytetrafluoroethylene, stainless steel and/or polyethylene as applicable to the type of sampling and constituents involved in the data collection program.

Special precautions, as outlined in the SOPs in the Generic FSP will be taken when collecting samples for per- and polyfluoroalkyl substances (PFAS) analysis.

The methods utilized by TRC for decontamination of sampling equipment are outlined in ECR 010, which is included in **Appendix B.**

4.0 ANALYTICAL METHODS AND QUALITY CONTROL SAMPLES

4.1 Analytical Parameters and Procedures

Samples collected during site characterization or remedial investigation activities will be properly labeled and shipped under proper chain-of-custody (COC) to the laboratory for analysis. Unless noted otherwise, samples will be analyzed by an NYSDOH ELAP-approved laboratory for one or more of the following NYSDEC DER-10 required analytical parameters:

- Target compound list (TCL) VOCs plus the 10 highest concentration tentatively identified compounds (TICs)
- TCL semivolatile organic compounds (SVOCs) plus 20 TICs
- TCL pesticides
- Herbicides
- Polychlorinated biphenyls (PCBs, Aroclors)
- Target analyte list (TAL) metals plus mercury and cyanide
- 1,4-Dioxane
- PFAS

For investigations of known petroleum releases, the suite of contaminants in the fuel oil and gasoline tables (i.e., Tables 2 and 3) of the NYSDEC Commissioner Policy CP-51 on Soil Cleanup Guidance and Spill Guidance Manual will be utilized.

For investigations of non-petroleum releases, sample analysis will use analytical methods appropriate for the stored or discharged material.

When sampling soil vapor, sub-slab vapor, crawl space air, indoor air or outdoor air, all samples will be analyzed by an NYSDOH ELAP-approved laboratory in accordance with USEPA-approved analytical methods utilizing the most current version of NYSDOH Guidance for Evaluating Soil Vapor Intrusion in the State of New York (Issued October 2006).

When sampling biota tissue, analysis of lipid content is required for all organochlorine compounds using USEPA Method 3540C Soxhlet extraction with a 1:1 hexane/acetone ratio or other approved method. The percent lipids will be quantified by the laboratory from the same aliquot as that used to quantify organochlorine concentrations.

A summary of the analytical methods, potential sample matrices, sample container types, sample preservation methods, and holding times is included **Appendix A**. Analyte lists associated with these analytical methods are summarized in **Appendix C**. Category B deliverables are typically required for all analytical results in order to perform complete validation of the results; limited exceptions may apply (i.e., disposal analyses).

4.2 Sampling Quality Control

This section of the QAPP identifies the QC procedures, checks, and samples that will be used to monitor the quality of various aspects of the sampling event.

4.2.1 Equipment Blanks

Internal quality control checks will include analysis of equipment blanks to check for procedural contamination at the site that may cause sample contamination. Equipment blanks will be prepared by pouring deionized water through or over sampling equipment after equipment decontamination and before field sample collection. Equipment blanks will be submitted at a frequency of one per day per type of non-dedicated equipment used and per parameter. It should be noted that equipment blanks will not be collected for the following parameters:

- VOCs in soil and sediment due to the lack of equipment used in collection (i.e., limited to EnCore® samplers, TerraCore® samplers, or syringes).
- Total organic carbon and pH in soil and sediment due to the nature of the analysis and intended use of the data.
- Geotechnical parameters associated with soil/sediment samples (e.g., grain size).
- All parameters associated with surface water samples due to the lack of equipment used in collection (i.e., direct filling of samples bottles for each parameter).
- All parameters associated with biota/tissue samples.
- Wet chemistry parameters.

4.2.2 Trip Blanks

For aqueous samples, trip blanks will be prepared by filling three 40-milliliter (mL) volatile organic analysis (VOA) vials with American Society for Testing and Materials (ASTM) Type II or equivalent water and preserving the samples with hydrochloric acid to a pH <2. Generally speaking, the laboratories provide trip blanks which would accompany the coolers from shipment from the labs through sample collection and sample return. Trip blank samples will be submitted to the laboratory with every cooler containing aqueous VOC samples and will only be analyzed for VOCs. Trip blanks will be used to evaluate contamination introduced during shipment. In all cases where sampling for PFAS is included in the program, TRC will ensure PFAS free water is utilized in the Trip Blanks.

4.2.3 Cooler Temperature Blanks

Cooler temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and are included in all coolers containing samples which require temperature preservation. The laboratory uses these temperature blanks to ensure that proper preservation of the samples has been maintained during sample shipment. The temperature of these blanks must be ≤6 ºC to demonstrate that proper preservation has been maintained. The laboratory records the results of the temperature blanks on the COC or sample log-in form immediately upon receipt of the samples at the laboratory, prior to inventory and refrigeration.

4.2.4 Field Duplicates

Field duplicates, or duplicate subsamples, are an additional aliquot of the same sample submitted for the same parameters as the original sample. Field duplicates will be used to assess the sampling and analytical reproducibility. Field duplicates will be collected by alternately filling sample bottles from the source being sampled. Field duplicates will be submitted at a frequency of one per 20 investigative samples, per matrix and analytical parameter. Field duplicates will not be collected for the biota/tissue matrix.

4.3 Laboratory Analytical Quality Control

This section identifies the QC procedures, checks, and samples that will typically be used during the project to monitor the quality of various preparatory and analytical steps by the laboratory. All required QC checks and QC samples and the associated QC acceptance limits are detailed in the associated analytical methods and laboratory SOPs.

4.3.1 Method Blanks

Method blanks will be performed as part of each analytical batch for each methodology performed. Method blanks are used to evaluate contamination introduced during sample preparation and/or analysis by the laboratory.

4.3.2 Instrument Blanks

Instrument blanks are used to evaluate contamination resulting from the analytical reagents and the instrumentation. In addition, instrument blanks are sometimes used to assess potential carryover after the analysis of a highly contaminated sample. Instrument blanks are only required for select analytical parameters.

4.3.3 Matrix Spike Samples

The matrix spike samples are used to determine laboratory preparation and analysis bias for specific compounds in specific matrices (i.e., sample specific QC). Matrix spikes are typically performed at a frequency of one per 20 investigative samples. Aqueous samples submitted for MS/MSD analyses for organic parameters require collection of triplicate volume. Aqueous samples submitted for MS analyses for inorganic parameters require collection of duplicate volume.

4.3.4 Surrogate Spikes

Surrogate spikes are used to evaluate extraction efficiency or analytical bias on a sample by sample basis for organic parameters. Surrogate spikes are added to all samples for organic parameters. Surrogate spikes are another measure of sample-specific QC.

4.3.5 Laboratory Control Samples

LCSs are used to evaluate select parameters for the ability of the laboratory to accurately identify and quantitate target compounds in a reference matrix when spiked with a known concentration using a secondary source standard. LCSs are typically performed as part of each analytical batch for each methodology. LCSs are also a self-check for the laboratory to ensure the method is in compliance.

4.3.6 Laboratory Duplicate

Laboratory duplicates are used to evaluate laboratory preparation and analysis precision. These analyses are typically performed for inorganic parameters only. Laboratory duplicates are typically performed at a frequency of one per 20 samples per matrix.

4.3.7 Matrix Spike Duplicate Samples

MSDs are used to evaluate laboratory preparation and analysis bias and precision for specific compounds in specific sample matrices (i.e., sample-specific QC). MSDs are typically performed for organic parameters only at a frequency of once per 20 samples per matric type.

4.3.8 Internal Standards

Internal standards are used to assess the analytical accuracy, precision, and stability. Internal standards are typically only used for gas chromatography/mass spectrometry analyses and inductively coupled plasma/mass spectrometry analyses. Internal standards are spiked into all samples and are considered a sample-specific QC measure.

5.0 SAMPLE COLLECTION DOCUMENTATION

Proper management and documentation of field and sampling activities is essential to ensure that all necessary work is conducted in accordance with the sampling plan and QAPP in an efficient and high-quality manner. Field management procedures will include following proper COC procedures to track a sample from collection through analysis, noting when and how samples are split (if required); completing COC Forms; completing Boring, Well and Test Pit Construction Logs; maintaining a daily Field Log Book; preparing Daily Field Activity Reports; completing Field Change Forms; and filling out a Daily Air Monitoring Form. Copies of each of these forms are provided in **Appendix D**. Proper completion of these forms and the field log book are necessary to support the consequent actions that may result from the sample analysis. This documentation will support that the samples were collected and handled properly.

5.1 Sample Identification

All samples will be identified using a unique sample identification scheme suitable to the site and sampling protocol and will be labeled with a sample identification code that is compatible with the NYSDEC EQuIS format. The code will identify the site, sample location, sample matrix and series numbers for sample locations with more than one sample. Samples will be labeled according to the following system:

Site:

Site name (i.e., Fashion Care Cleaning "FCC")

Sample Location:

MW – Monitoring Well
WS – Water Supply
SS – Surface Soil
SB – Soil Boring
DW – Dry Well
H – Hydropunch
P – Probe
TP – Test Pit
WET – Wetland

Sample Matrix (as listed in NYSDEC EQuIS reference values):

AE – Vapor Extraction Well Effluent
AI – Indoor Ambient Air
AO – Outdoor Ambient Air
AQ – Air Quality Control Matrix
AS – Soil Vapor
CA – Bottom Ash
CF – Fly Ash Cinder
SS – Surface Soil
SW – Swab or Wipe
TA – Animal Tissue
TP – Plant Tissue
TQ – Tissue Quality Control Matrix
U – Unknown
WC – Drilling Water (for well construction)

DC – Drill Cuttings
GE – Gaseous Effluent (Stack Gas)
GL – Headspace of Liquid sample
LD – Drilling Fluid
LE – Liquid Emulsion
LF – Floating/Free Product LNAPL
LS – DNAPL
SE – Sediment
SF – Filter Sand pack
SL – Sludge
SN – Miscellaneous Solid Materials
SO – Soil

WD – Well Development Water
WE – Estuary – Brackish Surface Water
WG – Groundwater
WH – Rinsate
WI – Interstitial Water
WL – Leachate
WO – Ocean Water – Saline Surface Water
WP – Drinking Water
WQ – Water Quality Control Matrix
WS – Surface Water
WW – Waste Water
WZ – Special Water Quality Control Matrix

<u>Sample Number</u>:

For circumstances where more than one sample of the same type and/or from the same location will be collected, a consecutive sample number will be assigned. When more than one sample is collected from a borehole in a sampling round at different depths, the depth will be indicated on the sample container and in the field log book.

<u>Field Duplicates:</u>

Will be submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01).

<u>QA/QC:</u>

MS – Matrix Spike
MSD – Matrix Spike Duplicate

EB – Equipment Blank
TB – Trip Blank

Based upon the above sample identification procedures, an example of a sample label may be:

Site — Sample Matrix — QA/QC

FCC-SB-SS-1-(5) - MS

Sample Location — Sample Number — Sample Depth

5.2 Chain-of-Custody

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

A sample is considered to be under a person's custody if:

- The item is in the actual possession of a person;
- The item is in the view of the person after being in actual possession of the person;
- The item was in the actual physical possession of the person but is locked up to prevent tampering; and,
- The item is in a designated and identified secure area.

5.3 Field Sample Custody

Sample handling is an important part of the field investigation program, since samples that are incorrectly handled can affect the quality of data. Sample handling begins at the collection of the sample and continues until the sample has been analyzed. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings, when pertinent) must be documented.

Sample COC and packaging procedures are summarized below. These procedures will ensure that the samples will arrive at the laboratory with the COC intact. The TRC Field Team Leader (or designee) is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field and up until the samples have been transferred to a courier. The COC procedures are initiated in the field immediately following sample collection. The procedures consist of: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the chain-of-custody form, and (3) preparing and packing the samples for shipment, as described in more detail below.

- The field sampler is personally responsible for the care and custody of the samples until they are transferred or dispatched properly. Field procedures have been designed such that as few people as possible will handle the samples.

- All bottles will be identified by the use of pre-printed adhesive sample labels with site name and location, sample locations, date/time of collection, type of preservation, type of analysis, and sampler's initials. The sample naming/numbering system is presented in Section 5.1.

- Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions. In addition, with the exception of VOC vials, sample labels will be covered with clear tape to minimize water damage during transit.

- Samples will be transported in containers (coolers) which will maintain the refrigeration temperature for those parameters for which refrigeration is required. Sample aliquots which require acidification will be checked with pH paper at the time of preservation. Confirmation of preservation will include capping of the preserved sample, repeated inversion (3x), uncapping and touching pH paper to the cap to confirm the sample pH. If required, additional preservative will be added, and the procedure repeated until proper preservation is achieved. For VOCs, the sample aliquot used to confirm preservation will not be submitted for analysis.

- Samples will be accompanied by a properly completed COC form. The sample numbers and locations will be listed on the COC form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage location.

- COC records are initiated by the samplers in the field. The field portion of the custody documentation should include: (1) the project name; (2) signatures of samplers; (3) the sample number, date and time of collection, and whether the sample is grab or composite; (4) signatures of individuals involved in sampling; and (5) if applicable, air bill or other shipping number.

- All shipments will be accompanied by the COC record identifying the contents. The original record will accompany the shipment, and copies will be retained by the sampler and placed in the project files.

- Samples will be shipped to the laboratory within 24 to 48 hours of sample collection using an overnight delivery service or via courier service. If analytical holding times are 24 to 48 hours from time of sample collection or if samples need to be preserved at the laboratory, samples will be shipped or picked up within 24 hours of sample collection using an overnight delivery service or courier service, respectively.

- Samples will be properly packaged for shipment and dispatched to the laboratory for analysis, with a separate signed custody record enclosed in and secured to the inside top of each sample box or cooler. Shipping containers will be secured for shipment to the laboratory. If an authorized laboratory courier does not pick up the samples from the project site, custody seals will be attached to the front right and back left of the cooler and covered with clear plastic tape after being signed by field personnel. Subsequently, the cooler will be strapped shut with strapping tape in at least two locations.

- If the samples are sent by common carrier, the air bill will be used. Air bills will be retained by the laboratory as part of the permanent documentation. Commercial carriers are not required to sign off on the custody forms since the custody forms will be sealed inside the sample cooler and the custody seals will remain intact.

- Samples remain in the custody of the sampler until transfer of custody is completed. This consists of delivery of samples to the laboratory sample custodian, and signature of the laboratory sample custodian on the COC document as receiving the samples and signature of sampler as relinquishing samples.

The procedures for shipping and packaging samples are also outlined in TRC's SOP: Packaging and Shipping of Non-Hazardous Environmental Samples and provided in **Appendix E**.

5.4 Field Log Book

Field logbooks will provide the means of recording the chronology of data collection activities performed during the investigation. As such, entries will be described in as much detail as possible so that a particular situation could be reconstructed without reliance on memory.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel but will be stored in the project files when not in use. Each logbook will be identified by the project-specific document number. All logbooks will be water resistant and have sequentially numbered pages.

The title page of each logbook will contain the following:

- Person to whom the logbook is assigned,
- The logbook number,
- Project name and number,
- Site name and location,

- Site location by longitude and latitude, if known,
- Project start date, and
- End date.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather, and names of all sampling team members present will be entered. Each page of the logbook will be signed and dated by the person making the entry. All entries will be made in permanent ink, signed, and dated and no erasures or obliterations will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler. The correction shall be written adjacent to the error.

Field activities will be fully documented. Information included in the logbook will include, but may not be limited to the following:

- Chronology of activities, including entry and exit times,
- Names of all people involved in sampling activities and organizational affiliations,
- Level of personal protection used,
- Any changes made to planned protocol,
- Names of visitors to the site during sampling and reason for their visit,
- Sample location and identification,
- Weather conditions, including temperature and relative humidity,
- Dates (month/day/year) and times (military) of sample collection,
- Measurement equipment identification (model/manufacturer) and calibration information,
- Field screening results,
- Site observations,
- Sample collection methods and equipment,
- Sample collection date and time,
- Sample depths,
- Whether grab or composite sample collected,
- How sample composited, if applicable,
- Sample description (color, odor, texture, etc.),
- Sample identification code,
- Tests or analyses to be performed,

- Sample preservation and storage conditions,
- Equipment decontamination procedures,
- QC sample collection,
- Unusual observations,
- Record of photographs,
- Sketches or diagrams (using permanent references and distances to the sampling point, if possible), and
- Signature of person recording the information.

Field logbooks will be reviewed on a daily basis by the TRC Field Team Leader. Logbooks will be supported by standardized forms. Examples of the forms are presented in **Appendix D**.

Upon receipt of the field logbook for a particular activity, the designated person recording the notes will begin recording notes on a new page. The person recording the notes will indicate the date, time, and weather conditions, prior to recording information about the field activity. The field logbook will indicate whether any field forms are used. When the designated person recording the notes either relinquishes the field logbook to another team member or turns the book in at the end of the day, the person relinquishing the field logbook will affix a signature and date to the bottom of the last page used. If the page is not complete, a diagonal line will be struck across the blank portion of the page.

5.5 Daily Field Activity Report

At the end of each day of field work, the Field Team Leader, or designee, will complete this report noting personnel on-site and summarizing the work performed that day, equipment, materials and supplies used, results of field analyses, problems and resolutions.

5.6 Field Changes and Corrective Actions

Whenever there is a required or recommended investigation/sampling change or correction, a Field Change Form will be completed by the Field Team Leader and approved by the Project Manager.

6.0 LABORATORY SAMPLE CUSTODY, SAMPLE RECEIPT, STORAGE, AND DISPOSAL PROCEDURES

Upon receipt of samples at the laboratory, the laboratory's sample custodian will inspect the samples for integrity and check the shipment against the COC. Discrepancies are reported to the laboratory's project manager who contacts the TRC project manager for resolution.

Samples will be received and logged in by a designated sample custodian or his/her designee. Upon sample receipt, the sample custodian will:

- Examine the shipping containers to verify that the custody seals are intact,
- Examine all sample containers for damage,
- Determine if the temperature required for the requested testing program has been maintained during shipment and document the temperature on the COC or sample log-in records,
- Compare samples received against those listed on the COC,
- Verify that sample holding times have not been exceeded,
- Examine all shipping records for accuracy and completeness,
- Determine sample pH (if applicable) and record on COC or sample log-in forms,
- Sign and date the COC immediately (if shipment is accepted) and attach the air bill,
- Note any problems associated with the coolers and/or samples on the cooler receipt form and notify the laboratory project manager, who will be responsible for contacting TRC,
- Attach laboratory sample container labels with unique laboratory identification and test, and
- Place the samples in the proper laboratory storage.

Following receipt, samples will be logged-in according to the following procedure:

- The samples will be entered into the laboratory tracking system. At a minimum, the following information will be entered: project name or identification, unique sample numbers (both client and internal laboratory), type of sample, required tests, date and time of laboratory receipt of samples, and field identification provided by field personnel.
- The laboratory project manager will be notified of sample arrival.
- The completed chain-of-custody, air bills, and any additional documentation will be placed in the final evidence file.

The laboratory's sample custodian will be responsible for sample storage and security to ensure that:

- Samples and extracts are stored for 60 days after the final analytical data report has been forwarded to TRC. The samples, extracts, and sample digestion byproducts are then discarded in accordance with Occupational Safety and Health Administration guidance; and,
- Samples are not stored with standards or sample extracts.

SOPs for laboratories to be utilized under the contract will be made available upon request.

7.0 CALIBRATION PROCEDURES AND PREVENTATIVE MAINTENANCE

Periodic preventive maintenance may be required for equipment. Instrument manuals will be kept on file for reference if equipment needs repair. The troubleshooting section of factory manuals may be used in assisting personnel in performing routine/minor maintenance tasks. The frequency of preventative maintenance for field equipment is indicated in each operating instruction manual.

The following information regarding equipment will be maintained at the project site:

- Equipment calibration and operating procedures which will include provisions for documentation of frequency, conditions, standards and records reflecting the calibration procedures, methods of usage and repair history of the measurement system. Calibration of field equipment will be performed daily at the sampling site so that any background contamination can be taken into consideration and the instrument calibrated accordingly.
- A schedule of preventive maintenance tasks, consistent with the instrument manufacturer's specific operation manuals that will be carried out to minimize down time of the equipment.
- Critical spare parts, necessary tools and manuals will be on hand to facilitate equipment maintenance and repair.

Calibration procedures and preventive maintenance for laboratory equipment will be contained in the laboratory's SOPs, which will be available upon request. Further information regarding the TRC Preventative Maintenance Program is included in **Appendix F**.

8.0 FIELD AUDITS

Audits of field activities may be conducted to verify that sampling and analysis are performed in accordance with the procedures established in the QAPP.

A system audit of field activities, including sampling and field measurements, may be conducted and documented by the TRC QAO (or his/her designee) at the start of sampling. The purpose of this audit is to verify that all established procedures are being followed as planned and documented and to allow for timely corrective action, reducing the impact of the nonconformance to the procedures described in the QAPP. The audit will ensure that all personnel have read the QAPP. The audit will cover field sampling records, field measurement results, field instrument operation and calibration records, sample collection, preservation, handling, and packaging procedures, adherence to QA procedures, personnel training, sampling procedures, decontamination procedures, review of sampling design versus the site-specific work plan, corrective action procedures, chain-of-custody, etc. Follow-up surveillance will be conducted by the TRC Field Team Leader to verify that QA procedures are maintained throughout the investigation.

Upon completion of the audit, the TRC QA Officer will prepare a written audit report, which summarizes the audit findings, identifies deficiencies and recommends corrective actions. In addition, a verbal debriefing will also be given to the TRC Field Team Leader and TRC Project Manager at the time of the audit. The written report will be submitted to the TRC Project Manager, who will be responsible for ensuring that corrective measures are implemented.

In addition to field audits, the Field Team Leader will provide oversight of any on-site subcontractors and report any issues to the TRC Project Manager.

A copy of the Field Audit Form is provided in **Appendix D**. Records of audits will be maintained in the project files.

9.0 DATA VALIDATION

An independent review of Category B laboratory data packages will be performed by TRC or a selected subcontractor, in order to determine the quality of the analytical data. Each data package will be reviewed for completeness to ensure it is in conformance with the QAPP requirements. Data validation will be performed in accordance with the guidance provided in NYSDEC DER-10, Appendix 2B, Guidance for Data Deliverables and the Development of Data Usability Summary Reports (DUSRs).

The DUSR is prepared by reviewing and evaluating the analytical data. The parameters to be evaluated in reference to compliance with analytical method protocols include all COC forms, holding times, preservation, raw data (instrument print out data and chromatograms), calibrations, blanks, spikes, surrogate recoveries, field duplicates, as applicable to the method.

The DUSR will describe the sample and analytical parameters reviewed. Data deficiencies, analytical protocol deviations and quality control problems will be described and their effect on the data discussed. The report will include the samples reviewed, a summary of associated field QC samples, and a discussion of the nonconformances with reference to the affected samples. The report will also include a discussion on how the nonconformance affects the achievement of the project objectives. Qualifiers applied to the data during preparation of the DUSR will be entered into the database. Validated data will be used to generate tables and figures.

The following data validation guidelines will be utilized for the DUSR preparation. These guidelines will be modified as needed to accommodate the specific analytical methodologies.

- USEPA National Functional Guidelines for Organic Superfund Methods Data Review (EPA-540-R-017-002), January 2017.
- USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review (EPA-540-R-2017-001), January 2017.
- USEPA National Functional Guidelines for High Resolution Superfund Methods Data Review (EPA-542-B-16-001), April 2016.
- USEPA Data Review and Validation Guidelines for Perfluoroalkyl Substances (PFASs) Analyzed Using EPA Method 537 (EPA 910-R-18-001), November 2018.
- New York State Department of Environmental Conservation Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids, January 2020.

Resampling and reanalysis recommendations will be made, if necessary.

10.0 CORRECTIVE ACTION

Corrective action for analytical work will include recalibration of instruments, reanalysis of known QC samples and, if necessary, reanalysis of actual field samples. Specific QC procedures and checklists will be in use by the analytical laboratory, designed to help analysts detect the need for corrective action. Often the person's experience will be valuable in alerting the operator to suspicious data or malfunctioning equipment.

If an immediate corrective action can be taken, as part of normal operating procedures, the collection of poor-quality data can be avoided. Instrument and equipment malfunctions are amenable to this type of action and the QC procedures include troubleshooting guides and corrective action suggestions. The actions taken will be noted in field or laboratory notebooks, but no other formal documentation is required, unless further corrective action is necessary. These on-the-spot corrective actions are an everyday part of the QA/QC system.

Corrective action during the field sampling portion of a program is most often a result of equipment failure or an operator oversight and may require recollection of a sample. Operator oversight is best avoided by having field crew members audit each other’s work before and after a test. Every effort will be made by the Field Team Leader to ensure that all QC procedures are followed.

If potential problems are not solved as an immediate corrective action, TRC will apply formalized long-term corrective action if necessary.

Documentation of the problem is important to the system. A Corrective Action Request Form will be filled out by the person finding the quality problem. This form identifies the problem, possible causes and the person responsible for action on the problem. The responsible person may be a laboratory analyst, field team leader, Laboratory QA Manager, or the TRC QAO. If no person is identified as responsible for the action, the TRC QAO investigates the situation and determines who is responsible in each case.

The Corrective Action Request Form includes a description of the corrective action planned and the date it was taken, and space for follow-up. The TRC QAO checks to be sure that initial action has been taken and appears effective and, at an appropriate later date, checks again to see if the problem has been fully solved. The TRC QAO receives a copy of all Corrective Action Request Forms. This permanent record aids the TRC QAO in follow-up and makes any quality problems visible to management; the log may also prove valuable in listing a similar problem and its solution.

10.1 Field Non-Conformances

Corrective action in the field may be needed when the sample network is changed (i.e., more/less samples, sampling locations other than those specified in the QAPP), or when sampling procedures and/or field analytical procedures require modification, etc. due to unexpected conditions. The field team may identify the need for corrective action. The TRC Field Team Leader will approve the corrective action and notify the TRC Project Manager. The TRC Field Team Leader will ensure that the corrective measure is implemented by the field team. Corrective actions will be implemented and documented in the field logbook. Documentation will include:

- A description of the circumstances that initiated the corrective action,
- The action taken in response,
- The final resolution, and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels. If necessary, a problem resolution audit will be conducted.

10.2 Laboratory Non-Conformances

Corrective action in the laboratory may occur prior to, during, and after initial analyses. Several conditions such as broken sample containers, omissions or discrepancies with chain-of-custody documentation, low/high pH readings, and potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with laboratory analysts and Laboratory Section Leaders, it may be necessary for the Laboratory QA Manager to approve the implementation of corrective action. The USEPA methods, and laboratory SOPs specify some conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include dilution of samples, additional sample extract cleanup, automatic reinjection/reanalysis when certain QC criteria are not met, etc.

The analyst may identify the need for corrective action. The Laboratory Section Leader, in consultation with the staff, will approve the required corrective action to be implemented by the laboratory staff. The Laboratory QA Manager will ensure implementation and documentation of the corrective action.

These corrective actions are performed prior to release of the data from the laboratory. The corrective action will be documented in both the laboratory's corrective action files, and the narrative data report sent from the laboratory to TRC. If the corrective action does not rectify the situation, the laboratory will contact the TRC QAO, who will determine the action to be taken and inform the appropriate personnel. If necessary, a problem resolution audit will be conducted.

10.3 Data Validation and Data Assessment Non-Conformances

The need for corrective action may be identified during either data validation or data assessment. Potential types of corrective action may include resampling by the field team or reinjection/reanalysis of samples by the laboratory. These actions are dependent upon the ability to mobilize the field team and whether the data to be collected are necessary to meet the required QA objectives. If the data validator or data assessor identifies a corrective action situation, the TRC Project Manager will be responsible for informing the appropriate personnel. All corrective actions of this type will be documented by the TRC Project Manager and maintained in the project files.

Appendix A
Summary of Monitoring Parameters

Appendix A: Analytical Methods, Preservation, Holding Times and Sample Containers					
Field Sample Matrix	**Parameter**	**Analytical Method References**	**Sample Preservation**	**Holding Time from Collection**	**Container**
Soil/Sediment	PFAS	Laboratory's specific PFAS SOP based on EPA Method 537.1 (isotope dilution)	Cool, 4ºC, not frozen and samples must not exceed 10ºC during the first 48 hours after collection.	14 days to extraction; 28 days from extraction to analysis	2-4 oz HDPE bottles with HDPE screw caps
Soil/Sediment	TCL VOCs	SW-846 5035A/8260C	Methanol-preserved in the field and cool to 4°C (high-level); and water-preserved in the field and cool to 4ºC (low-level). (Soil/preservative ratio: 1:1)	High-level: 14 days to analysis Low-level: 48 hours to freezing at < -7ºC; 14 days to analysis	2-40 mL methanol-preserved VOA vials (high-level); or 2-40 mL vials with laboratory reagent water and magnetic stir bar (low-level)
Soil/Sediment	TCL SVOCs	SW-846 8270D	Cool to 4°C	14 days to extraction; 40 days from extraction to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	TPH-DRO	SW-846 8015C	Cool to 4°C	14 days to extraction; 40 days from extraction to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	TPH-GRO	SW-846 8015C	Methanol-preserved in the field and cool to 4°C	14 days to analysis	2-40 ml methanol-preserved VOA vials
Soil/Sediment	TCL Pesticides	SW-846 8081B	Cool to 4°C	14 days to extraction; 40 days from extraction to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	PCB Aroclors	SW-846 8082A	Cool to 4°C	14 days to extraction; 40 days from extraction to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	Herbicides	SW-846 8151A	Cool to 4°C	14 days to extraction; 40 days from extraction to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	TAL Metals	SW-846 6010C/6020A/7471B	Cool to 4°C	Mercury: 28 days to analysis Other Metals: 180 days to analysis	1-8 oz polyethylene/ glass bottle and cap
Soil/Sediment	Cyanide	SW-846 9010C/9014	Cool to 4°C	14 days to analysis	1-8 oz polyethylene/glass bottle and cap
Soil/Sediment	Hexavalent Chromium	SW-846 3060A/7196A	Cool to 4°C	30 days to extraction; 7 days from extraction to analysis	1-4 oz glass jar with Teflon-lined cap
Soil/Sediment	pH	SW-846 9045D	Cool to 4°C	24 hours to analysis	1-4 oz glass jar with Teflon-lined cap
Soil/Sediment	ORP	ASTM Method D 1498-00, modified	Cool to 4°C	24 hours to analysis	1-4 oz glass jar with Teflon-lined cap

Appendix A: Analytical Methods, Preservation, Holding Times and Sample Containers					
Field Sample Matrix	**Parameter**	**Analytical Method References**	**Sample Preservation**	**Holding Time from Collection**	**Container**
Soil/Sediment	Corrosivity	SW-846 9045D	Cool to 4°C	24 hours to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	Ignitability	SW-846 1030/ASTM Method D93-12	Cool to 4°C	None	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	TCLP or SPLP VOCs	SW-846 1311 or 1312/5030B/8260C	Cool to 4°C No headspace	14 days to analysis	1-4 oz glass jar with Teflon-lined cap
Soil/Sediment	TCLP or SPLP SVOCs	SW-846 1311 or 1312/3510C/8270D	Cool to 4°C	14 days to TCLP/SPLP extraction; 7 days from TCLP/SPLP extraction to SVOC extraction; 40 days from SVOC extraction to analysis	1-8 oz glass jar with Teflon-lined cap
Soil/Sediment	TCLP or SPLP Metals	SW-846 1311 or 1312/3005A, 3015A/6010C/7470A	Cool to 4°C	Mercury: 28 days Other metals: 180 days to analysis	1-8 oz glass bottle and cap
Soil/Sediment	Reactive Cyanide	SW-846 Update III Chapter 7, Section 7.3.4	Cool to 4°C; no headspace	3 days to analysis	1-4 oz amber glass jar with Teflon-lined cap
Soil/Sediment	Reactive Sulfide	SW-846 Update III Chapter 7, Section 7.3.3	Cool to 4°C; no headspace	3 days to analysis	1-4 oz amber glass jar with Teflon-lined cap
Groundwater/ Surface water	PFAS	Laboratory's specific PFAS SOP based on EPA Method 537.1 (isotope dilution)	Cool, 4ºC, not frozen and samples must not exceed 10ºC during the first 48 hours after collection.	14 days to extraction; 28 days from extraction to analysis	2-250 mL HDPE bottles with HDPE screw caps
Groundwater/ Surface water	TCL VOCs	SW-846 5030B/8260C	Cool to 4°C HCl to pH<2	14 days to analysis	2-40 mL VOA vials
Groundwater/ Surface water	TCL SVOCs	SW-846 8270D	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	1,4-Dioxane	SW-846 8270D with SIM/isotope dilution	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	TPH-DRO	SW-846 8015C	pH <2 with HCl; cool to 4°C	14 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	TPH-GRO	SW-846 8015C	Cool to 4°C HCl to pH<2	14 days to analysis	2-40 mL VOA vials

Appendix A: Analytical Methods, Preservation, Holding Times and Sample Containers					
Field Sample Matrix	**Parameter**	**Analytical Method References**	**Sample Preservation**	**Holding Time from Collection**	**Container**
Groundwater/ Surface water	TCL Pesticides	SW-846 8081B	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	PCB Aroclors	SW-846 8082A	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	Herbicides	SW-846 8151A	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	2-1 L amber glass bottles with Teflon-lined cap
Groundwater/ Surface water	Metals	SW-846 6010C/6020A/7470A	pH <2 with HNO_3; cool to 4°C	Mercury: 28 days to analysis Other Metals: 180 days to analysis	1-1 L polyethylene/glass container
Groundwater/ Surface water	Cyanide	SW-846 9010C/9014	Cool to 4°C; NaOH to pH >12	14 days to analysis	1-1 L glass or polyethylene bottle and cap
Groundwater/ Surface water	Hexavalent Chromium	SW-846 7196A	Cool to 4°C	24 hours to analysis	1-1 L glass or polyethylene bottle and cap
Air	VOCs	EPA Method TO-15	None	30 days to analysis	1 pre-cleaned, evacuated, passivated stainless steel canister
Air	PAHs	EPA Method TO-13A	Cool to 4°C	7 days to extraction; 40 days from extraction to analysis	1 quartz-fiber filter/PUF plug/XAD-2 resin
Bulk	Asbestos	EPA/600/R-93/116 (July 1993)	None	None	1 Ziploc bag
Paint Chips	Lead	SW-846 7000B	None	None	1 Ziploc bag

Appendix B
TRC SOP ECR010 – Equipment Decontamination

Title: **Equipment Decontamination**		Procedure Number: **ECR 010**
		Revision Number: **1**
		Effective Date: **December 2016**

Authorization Signatures			
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
James Peronto	12/15/16	Elizabeth Denly	12/15/16

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the procedures needed for decontamination of equipment used in the field during environmental investigations (e.g., sediment, soil, groundwater investigations). Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination.

The use of dedicated, disposable, new sampling equipment (e.g., disposable liners, plastic spoons, plastic or aluminum bowls) should be considered as an alternative to equipment decontamination and the subsequent generation of decontamination fluids.

1.2 Summary of Method

Equipment decontamination is used to remove potential contaminants from a sampling device or piece of field equipment prior to and between the collection of samples and is also used to limit personnel exposure to residual contamination that may be present on used field equipment.

Contaminants can be physically removed from equipment or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and nonabrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water, followed by a wash/rinse process using appropriate cleaning solutions. A solvent rinse may be required when organic contamination is present, and an acid rinse may be required when metals are parameters of interest. Equipment decontamination procedures can vary depending on the media being sampled and the type of sampling equipment being used. Disposal of decontamination fluids will be handled on a project-specific basis and will be in accordance with all applicable regulations.

1.3 Equipment

The following equipment may be utilized when decontaminating equipment. Project-specific conditions or requirements may warrant the use of additional equipment or deletion of items from this list. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment B for further details.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)

- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate (may be supplied by the laboratory or purchased from commercial vendors depending on project requirements)
- Pump sprayer
- Pressure sprayer
- Squeeze bottle filled with pesticide-grade hexane (option for organic analyses)
- Squeeze bottle filled with pesticide-grade methanol (option for organic analyses)
- Squeeze bottle filled with pesticide-grade isopropanol (option for organic analyses)
- Squeeze bottle filled with 10 percent nitric acid (option for metals analyses and stainless-steel equipment)
- Squeeze bottle filled with 1 percent nitric acid (option for metals analyses)
- Container (squeeze bottle to 5-gallon bucket) filled with potable water and a nonphosphate, laboratory-grade soap (approximately 1 tablespoon of soap to 5 gallons of water)
- Extra quantities of above listed liquids
- Potable water
- Containers, such as buckets or wash basins (the type and number of containers is dependent on the procedure)
- Scrub brushes
- Small wire brush
- Aluminum foil
- Polyethylene sheeting
- A container for decontamination of pumps and associated tubing.

1.4 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

Samples containing chemical contaminants may be handled during implementation of this SOP. Certain decontamination fluids, including solvents and/or acids, are considered hazardous materials, and TRC employees will appropriately handle and store them at all times. Appropriately manage chemicals that pose specific toxicity or safety concerns, and follow any other relevant requirements as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Some hazardous substances may be incompatible with clothing or equipment and can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through

inhalation or skin contact or if exposed to heat/flame and they combust. Safety data sheets for chemicals handled by TRC personnel should be maintained in a designated location at the project site.

1.5 Cautions and Potential Problems

Special care should be taken when decontaminating equipment used for sampling for PFAS. Please refer to Attachment B for details.

- The use of deionized, distilled or organic-free water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been certified by the vendor as analyte-free and/or meets the project-specific requirements.

- Alconox®, Liquinox®, or other nonphosphate, concentrated, laboratory-grade soap may contain trace quantities of perchlorate.

- Avoid using an excessive amount of soap during decontamination procedures, as this could result in difficulty rinsing the soap residue off of the equipment. Typically the soap solution is prepared using 1 tablespoon of soap to 5 gallons of water.

- Use sufficient amount of decontamination fluid (e.g., acid or solvent rinses) so that the fluid flows over the equipment and runs off. Spraying the equipment with a minimal amount of decontamination fluid that does not run off is ineffective.

- Spent decontamination solutions are considered investigation-derived waste (IDW) and must be managed as directed by the site-specific field program. Project and regulatory requirements, chemical compatibility, ambient conditions and professional judgment should be used to determine the appropriate decontamination process with respect to combining and/or segregating decontamination fluids. Section 3 of this SOP provides more guidance on the disposal procedures.

- Several procedures can be established to minimize the potential for cross-contamination or analytical interference by decontamination fluids. For example:

  - The use of methanol in the decontamination procedure may not be appropriate if methanol is a contaminant of concern.

  - Isopropanol may be used as a substitute for methanol but may not be appropriate when collecting samples for volatile organic compound (VOC) analyses. Residual isopropanol on the equipment may cause substantial interferences in subsequent VOC analyses and may result in unnecessary dilutions and/or false positive results if isopropanol is not removed in subsequent decontamination steps. It should also be noted that the application of isopropanol to hot metal surfaces (e.g., a steam-cleaned split spoon) may cause oxidation of the isopropanol to acetone.

- If hexane is used in the decontamination procedure, caution should be used to ensure that the hexane is completely volatilized and the equipment is subsequently rinsed when samples are to be analyzed for VOCs and volatile petroleum hydrocarbons (VPH). Residual hexane on equipment could interfere with the VOC and VPH analyses and may result in unnecessary dilutions and/or false positive results.

- Cover monitoring and sampling equipment with protective material (i.e., aluminum foil, polyethylene sheeting, or Ziploc® bags) to minimize potential re-contamination after decontamination.

- Use disposable sampling equipment when appropriate to minimize the need for decontamination. Although disposable sampling tools are encouraged in order to minimize the generation of decontamination fluids, it should be noted that plastic tools may not be appropriate for collection of samples to be analyzed for semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Potential phthalate contamination may cause significant interferences in the subsequent analyses and may result in unnecessary dilutions and/or false positive results.

- After decontamination, equipment should be handled only by personnel wearing clean disposable powder-free nitrile gloves to prevent recontamination.
- If equipment decontamination is performed in the field, the equipment should be moved away (preferably upwind) from the decontamination area to prevent recontamination.
- Equipment that is not decontaminated properly may result in potentially high biased results in field samples. **Note:** Equipment blank collection may be appropriate after decontamination of equipment used to collect highly contaminated samples.

1.6 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Refer to the site-specific sampling plan and/or Quality Assurance Project Plan (QAPP), if applicable, for site-specific procedures. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed if applicable. In all instances, the actual procedures used should be documented and described in the field notes.

2.1 General

All personnel, sample containers, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants by abrasive and/or washing actions, inactivate contaminants by disinfection or sterilization, or both. Decontamination procedures should be documented in the field book.

2.2 Physical Decontamination Procedures

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and nonabrasive methods. In general, heavy equipment decontamination is conducted by drilling and construction subcontractors and not by TRC personnel. However, TRC personnel will typically need to document such decontamination efforts as part of project work.

ABRASIVE CLEANING METHODS APPROPRIATE FOR DRILLING EQUIPMENT (DRILLING RIGS, ETC.)

Abrasive cleaning methods involve rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available but are not commonly used:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- *Air Blasting:* Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs, or auger bits. The equipment used in air blasting employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive material strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages, including it is unable to control the amount of materials removed, it can aerate contaminants, and it generates large amounts of waste.

- *Wet Blasting:* Wet blasting, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. One disadvantage of this method is the generation of a large amount of waste.

NONABRASIVE CLEANING METHODS APPROPRIATE FOR FIELD EQUIPMENT (DRILLING AUGERS AND RIGS, ETC.)

Nonabrasive cleaning methods involve forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using nonabrasive methods. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. The following non-abrasive methods are available:

- *High-pressure Potable Water:* This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high-pressure hose. Flow rates typically range from 20 to 140 liters per minute.

  This procedure is used the majority of the time and is more appropriate for equipment with painted surfaces.

- *Ultrahigh-Pressure Potable Water:* This system produces a pressurized water jet. The ultrahigh-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 meters per second (m/sec) to 900 m/sec. Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

  This procedure is not commonly used but would be appropriate for carbon steel drilling rods and augers.

2.3 Procedure for Sampling Equipment

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details. **Note:** The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. The number of decontamination steps and designated containers should be determined prior to field sampling based on the site-specific sampling plan. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. If more than one, the nonwater rinsate fluids may need to be separated. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. Place the containers on the polyethylene sheeting. The decontamination line should progress from “dirty” to “clean”.

   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.

2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container. Do not use an excessive amount of the soap (approximately 1 tablespoon of soap to 5 gallons of water), or rinsing the soap residue off of the equipment will be difficult.

3. Brush any visible dirt off of the sampling equipment into a designated area before getting equipment wet.

4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container, removing all dirt or visible hydrocarbons. Allow excess soap to drain off the equipment into the container when finished. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

5. Rinse the equipment with potable water over an appropriate container, using a coarse scrub brush or pressure sprayer to aid in the rinse if necessary. If an additional acid or solvent rinse is not required, proceed to Step 8.

6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.

   Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Cautions and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.

   Allow the equipment to completely air dry prior to proceeding to the next step.

   **** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.**

8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water. If cleaning a pump that is not completely disassembled, run the submerged pump in the container long enough to allow sufficient contact time with the internal components of the pump.

9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container) (See*NOTE).

   ***NOTE** that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water

should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field book or on the appropriate form.

10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.

11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

12. Record the decontamination procedure in the field book or on the appropriate form.

2.4 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers, water level indicators, oil/water interface probes, and soil moisture/pH meters will be cleaned using the following procedure, unless it conflicts with the manufacturer's recommendations. Special care should be taken during decontamination procedures following sampling for PFAS. Please refer to Attachment B for details.

1. Fill two clean containers (e.g., plastic wash basins or buckets) with potable water.

2. Add sufficient nonphosphate concentrated laboratory-grade soap to one container to form a thin layer of soap suds. If oily residues are apparent, the use of Simple Green® may be required.

3. Brush any visible dirt off of the measuring equipment before getting the equipment wet.

4. Either spray rinse the device with the soap solution over the first container, or for heavily soiled equipment, immerse the device in the container containing soap and gently agitate. Scrub device if it is soiled. Do not submerse any electrical controls or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

5. Immerse the device in the container containing the potable water and gently agitate. Do not submerse any electrical connectors or take-up reels. Submerse only that portion of the device that came in contact with potential contaminants.

6. Spray rinse equipment with deionized, distilled, or organic-free water over the last container used.

7. Allow the equipment to air dry if time allows.

8. Record the decontamination procedure in the field book or on the appropriate form.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for IDW disposal with the Project Manager.

Each project must consider IDW disposal methods and have a plan in place prior to performing the field work. Provisions must be in place regarding what will be done with IDW. If IDW cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the equipment blank. The equipment blank provides information about the effectiveness of the decontamination process employed in the field. An equipment blank can detect contamination that may arise from potentially contaminated equipment or equipment that has not been decontaminated effectively.

Equipment blanks consist of a sample of analyte-free (i.e., deionized, distilled, organic-free) water that is poured over and through a decontaminated sampling device and placed in a clean sample container. Ideally, the reagent water should come from the laboratory and be certified as clean. If the blank water is not certified as clean and/or not supplied by the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should also be sent to the laboratory for analysis.

Equipment blanks are typically collected for all parameters of interest at a minimum rate of 1 per 20 samples for each parameter. The frequency of equipment blank collection will vary from project to project, depending upon the data quality objectives, and will be specified in either the site-specific sampling plan or QAPP. Equipment blanks are typically not required if dedicated sampling equipment is used.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or on the appropriate form. Any deviations from the decontamination procedures specified in the sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field book. Refer to RMD SOP 001 for field documentation procedures.

6.0 REFERENCES

USEPA. December 1987. *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001.

USEPA. January 1991. *Compendium of ERT Groundwater Sampling Procedures*. OSWER Directive 9360.4-06. PB91-9211275.

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. January 1999. *Compendium of ERT Groundwater Sampling Procedures*. EPA/540/P-91/007. OSWER Directive 9360.4-06. PB91-921275.

USEPA. December 20, 2011. *Field Equipment Cleaning and Decontamination*. SESDPROC-205-R2. Region 4. Science and Ecosystems Support Division. Athens, Georgia.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
1	DECEMBER 2016	ADDED ATTACHMENT B TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFAS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.

Attachment A: SOP Fact Sheet

EQUIPMENT DECONTAMINATION

PURPOSE AND OBJECTIVE

Removing or neutralizing potential contaminants that may have accumulated on equipment and vehicles ensures protection of personnel, reduces or eliminates potential transfer of contaminants to clean areas, and minimizes the likelihood of sample cross-contamination. Preventing or minimizing potential cross-contamination of samples is important for the collection of representative samples, avoiding the possible introduction of sampling error into sample results, and for protecting the health and safety of site personnel.

WHAT TO BRING

- Field book
- Appropriate PPE
- Site-specific HASP
- Alconox®, Liquinox® or other nonphosphate concentrated laboratory-grade soap
- Simple Green® or other nontoxic biodegradable cleaner
- Deionized, distilled, or organic-free water, as appropriate
- Potable water (or water containers if potable water source on site or nearby)
- Pump or pressure sprayer
- Squeeze bottles filled with appropriate decontamination chemicals (e.g., organic solvents, nitric acid)
- Containers, such as buckets or wash basins (type and number is dependent on the procedure)
- Scrub brushes
- Aluminum foil
- Polyethylene sheeting

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the latest version.
- Review site-specific sampling plan/QAPP for decontamination procedures and procedures for management of investigation-derived waste (IDW) (e.g., used decontamination solutions).
- Confirm all required decontamination supplies are in stock or order as needed.

ON-SITE

- Verify project HASP including safety data sheets for decontamination chemicals used on site.
- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Establish a designated equipment and personnel decontamination area.
- Provide for the proper collection and management of all IDW.
- Verify that appropriate PPE is worn by all site personnel (including subcontractors) and the work area is safe.

SAMPLING EQUIPMENT DECONTAMINATION - PROCEDURES

Sampling equipment, such as split-spoon samplers, shovels, hand augers, trowels, spoons, spatulas, bailers, tethers, dippers, and pumps, will be cleaned using the following procedure. **A more simplified procedure for decontamination of measuring equipment is presented in the SOP.** Note: The overall number of containers needed for collection of decontamination fluids may vary depending on chemical compatibilities, project and regulatory requirements, and ultimate disposal methods for these fluids.

1. Lay out sufficient polyethylene sheeting on the ground or floor and the necessary number of containers (e.g., plastic wash basins or buckets) and an air drying area. At a minimum, one container should be designated for the detergent wash. A second container should be designated for water rinsing. A third container may be designated for nonwater rinsing. Nonwater rinsate fluids should not be combined with the detergent wash during decontamination. The decontamination line should progress from "dirty" to "clean".
   Note: In instances where acid or solvent rinses are required, additional containers may be needed to manage collection and subsequent disposal of the spent decontamination fluids.
2. Fill the first container with potable water. Add sufficient nonphosphate concentrated laboratory-grade soap to cause suds to form in the container.
3. Brush any visible dirt off of the sampling equipment before getting equipment wet.
4. Using a clean, coarse scrub brush, submerge and wash the sampling equipment in the soap solution in the first container.

EQUIPMENT DECONTAMINATION

5. Rinse the equipment with potable water over an appropriate container. If an additional acid or solvent rinse is not required, proceed to Step 8.
6. **If sampling for metals and if required by the project, rinse the equipment with nitric acid over an appropriate container. Consider using a container dedicated to acidic solutions to minimize the volume of liquid that needs to be neutralized later. A 10 percent nitric acid solution is used on stainless steel equipment. A 1 percent nitric acid solution is used on all other equipment. If not required, this step may be omitted.
7. **If sampling for organic parameters and if required by the project, rinse the equipment over an appropriate container using pesticide-grade methanol or isopropanol (see Caution and Potential Problems). If oily, a pesticide-grade hexane rinse should follow the methanol/isopropanol rinse, or as an alternative, Simple Green® can be used if approved by the Project Manager. Consider using an appropriate container dedicated to volatile solvents to minimize the volume of liquid that subsequently needs to be managed as IDW. If not required, this step may be omitted.
   Allow the equipment to completely air dry prior to proceeding to the next step.
   ** Steps 6 and 7 are optional and may be used on a site-specific basis. The site-specific sampling plan or QAPP, if available, should be consulted. In the absence of a sampling plan or QAPP, the Project Manager will decide upon the necessity of these steps.
8. Rinse the equipment over an appropriate container using deionized, distilled or organic-free water.
9. Allow the equipment to completely air dry on a clean surface (e.g., polyethylene sheeting or a clean container).
   *NOTE that if temperature or humidity conditions preclude air drying equipment, sufficient spares, if possible, should be available so that no item of sampling equipment need be used more than once. If an ample amount of spare equipment is not available and the equipment will not completely air dry, additional rinses with deionized, distilled or organic-free water should be used. The inability of equipment to air dry and the usage of additional rinses should be recorded in the field logbook or on the appropriate form.
10. Reassemble equipment, if necessary, and wrap completely in clean, unused, protective material. Reuse of equipment on the same day without wrapping in protective material is acceptable.
11. Spent decontamination fluids are considered IDW and must be managed as directed by the site-specific field program.

INVESTIGATION DERIVED WASTE (IDW) DISPOSAL

Field personnel should review the project work plan and ensure project-specific IDW management documentation and containerization requirements are specified or discussed with the Project Manager before going to the project site.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All reagents used must be documented in the field book or an appropriate field form. Any deviations from the decontamination procedures specified in the work plan, sampling plan or QAPP must be approved by the Quality Assurance (QA) Officer and Project Manager and documented in the field book. The lot number and vendor of each reagent used should be documented in the field logbook. Refer to RMD SOP 001 for field documentation procedures.

DOs AND DO NOTs OF EQUIPMENT DECONTAMINATION

DOs:

- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them on site work.
- DO manage and collect IDW in accordance with project requirements.
- DO use deionized, distilled or analyte free water that is provided by the laboratory, is certified analyte-free, and/or meets project requirements.
- DO use sufficient amount of decontamination fluids so that the fluid flows over the equipment and runs off.
- DO use new wrapped disposable dedicated sampling equipment when appropriate to minimize the need for decontamination.

DO NOTs:

- DO NOT use an excessive amount of soap during decontamination.
- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc.; call PM if this issue arises.

Attachment B: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Equipment Decontamination Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Use only Alconox® or Liquinox® soap; do not use Decon 90. • Use new plastic buckets for wash and rinse water. • Ensure that PFAS-free water is used during the decontamination procedure. • Do not use aluminum foil.
1.5	Always consult the Site-specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to decontamination procedures: • Tyvek® suits should not be worn. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Food and drink should not be allowed within the decontamination area. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only. • Personnel involved with decontamination should wear a new pair of nitrile gloves after each decontamination procedure when handling equipment to avoid re-contamination. Avoid handling unnecessary items with nitrile gloves. • Do not store on or cover equipment with aluminum foil after decontamination. Use of polyethylene sheeting is acceptable. • Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended six washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering the morning of sampling and decontamination field work.
2.2	• New nylon or metal bristle brushes should be used for mechanical cleaning methods. • If high-pressure water is used, it must be tested prior to use for presence of PFAS.
2.3	• Ensure that PFAS-free water is used during the decontamination procedure.
2.4	• Ensure that PFAS-free water is used during the decontamination procedure.

Appendix C
Summary of Constituents Included in Analyses

Appendix C: Summary of Constituents Included in Analyses - Emerging Contaminants			
Method (Matrix)	**Chemical Name**	**Abbreviation**	**CAS Number**
Modified 537.1/ Lab SOP (AQ) Lab SOP (SO)	Perfluorobutanesulfonic acid	PFBS	375-73-5
	Perfluorohexanesulfonic acid	PFHxS	355-46-4
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanesulfonic acid	PFOS	1763-23-1
	Perfluorodecanesulfonic acid	PFDS	335-77-3
	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	PFHpA	375-85-9
	Perfluorooctanoic acid	PFOA	335-67-1
	Perfluorononanoic acid	PFNA	375-95-1
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUA/PFUdA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTriA/PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTA/PFTeDA	376-06-7
	6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2
	8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4
	Perfluororoctanesulfonamide	FOSA	754-91-6
	N-methyl perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethyl perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6
8270D SIM (AQ) 8270D (SO)	1,4-Dioxane	-	123-91-1

Appendix C: Summary of Constituents Included in Analyses - TCL VOCs		
Method (Matrix)	**Chemical Name**	**CAS Number**
8260C/D (AQ and SO)	1,1,1-Trichloroethane	71-55-6
	1,1,2,2-Tetrachloroethane	79-34-5
	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1
	1,1,2-Trichloroethane	79-00-5
	1,1-Dichloroethane	75-34-3
	1,1-Dichloroethene	75-35-4
	1,2,3-Trichlorobenzene	87-61-6
	1,2,4-Trichlorobenzene	120-82-1
	1,2-Dibromo-3-Chloropropane	96-12-8
	1,2-Dibromoethane	106-93-4
	1,2-Dichlorobenzene	95-50-1
	1,2-Dichloroethane	107-06-2
	1,2-Dichloropropane	78-87-5
	1,3-Dichlorobenzene	541-73-1
	1,4-Dichlorobenzene	106-46-7
	2-Hexanone	591-78-6
	Acetone	67-64-1
	Benzene	71-43-2
	Bromodichloromethane	75-27-4
	Bromochloromethane	74-97-5
	Bromoform	75-25-2
	Bromomethane	74-83-9
	Carbon Disulfide	75-15-0
	Carbon Tetrachloride	56-23-5
	Chlorobenzene	108-90-7
	Chloroethane	75-00-3
	Chloroform	67-66-3
	Chloromethane	74-87-3
	Cis-1,2-Dichloroethylene	156-59-2
	Cis-1,3-Dichloropropene	10061-01-5
	Cyclohexane	110-82-7
	Dibromochloromethane	124-48-1
	Dichlorodifluoromethane	75-71-8
	Ethylbenzene	100-41-4
	Isopropylbenzene	98-82-8
	Methyl Acetate	79-20-9
	2-Butanone	78-93-3
	4-Methyl-2-Pentanone	108-10-1
	Methylcyclohexane	108-87-2
	Methylene Chloride	75-09-2
	Styrene	100-42-5
	Methyl Tert-Butyl Ether	1634-04-4
	Tetrachloroethylene	127-18-4
	Toluene	108-88-3
	Trans-1,2-Dichloroethene	156-60-5
	Trans-1,3-Dichloropropene	10061-02-6
	Trichloroethylene	79-01-6
	Trichlorofluoromethane	75-69-4
	o-Xylene	95-47-6
	m,p-Xylene	179601-23-1
	Vinyl Chloride	75-01-4

Appendix C: Summary of Constituents Included in Analyses - TCL SVOCs		
Method (Matrix)	**Chemical Name**	**CAS Number**
8270D/E (AQ and SO)	1,4-Dioxane	123-91-1
	2,4,5-Trichlorophenol	95-95-4
	2,4,6-Trichlorophenol	88-06-2
	2,4-Dichlorophenol	120-83-2
	2,4-Dimethylphenol	105-67-9
	2,4-Dinitrophenol	51-28-5
	2,4-Dinitrotoluene	121-14-2
	2,6-Dinitrotoluene	606-20-2
	2-Chloronaphthalene	91-58-7
	2-Chlorophenol	95-57-8
	2-Methylnaphthalene	91-57-6
	2-Methylphenol	95-48-7
	2-Nitroaniline	88-74-4
	2-Nitrophenol	88-75-5
	3,3'-Dichlorobenzidine	91-94-1
	3-Nitroaniline	99-09-2
	4,6-Dinitro-2-Methylphenol	534-52-1
	4-Bromophenyl Phenyl Ether	101-55-3
	4-Chloro-3-Methylphenol	59-50-7
	4-Chloroaniline	106-47-8
	4-Chlorophenyl Phenyl Ether	7005-72-3
	3/4-Methylphenol	108-39-4/106-44-5
	4-Nitroaniline	100-01-6
	4-Nitrophenol	100-02-7
	Acenaphthene	83-32-9
	Acenaphthylene	208-96-8
	Acetophenone	98-86-2
	Anthracene	120-12-7
	Atrazine	1912-24-9
	Benzaldehyde	100-52-7
	Benzo(a)Anthracene	56-55-3
	Benzo(a)Pyrene	50-32-8
	Benzo(b)Fluoranthene	205-99-2
	Benzo(g,h,i)Perylene	191-24-2
	Benzo(k)Fluoranthene	207-08-9
	Butyl Benzyl Phthalate	85-68-7
	1,1'-Biphenyl	92-52-4
	Bis(2-Chloroethoxy) Methane	111-91-1
	Bis(2-Chloroethyl) Ether	111-44-4
	2,2'-Oxybis (1-chloropropane) (bis-[2-chloroisopropyl]ether)	108-60-1
	Bis(2-Ethylhexyl) Phthalate	117-81-7
	Caprolactam	105-60-2
	Carbazole	86-74-8
	Chrysene	218-01-9
	Dibenz(a,h)anthracene	53-70-3
	Dibenzofuran	132-64-9
	Diethyl Phthalate	84-66-2
	Dimethyl Phthalate	131-11-3
	Di-n-Butyl Phthalate	84-74-2
	Di-n-Octylphthalate	117-84-0

Appendix C: Summary of Constituents Included in Analyses - TCL SVOCs		
Method (Matrix)	**Chemical Name**	**CAS Number**
8270D/E (AQ and SO)	Fluoranthene	206-44-0
	Fluorene	86-73-7
	Hexachlorobenzene	118-74-1
	Hexachlorobutadiene	87-68-3
	Hexachlorocyclopentadiene	77-47-4
	Hexachloroethane	67-72-1
	Indeno(1,2,3-c,d)Pyrene	193-39-5
	Isophorone	78-59-1
	Naphthalene	91-20-3
	Nitrobenzene	98-95-3
	N-Nitrosodi-N-Propylamine	621-64-7
	N-Nitrosodiphenylamine	86-30-6
	Pentachlorophenol	87-86-5
	Phenanthrene	85-01-8
	Phenol	108-95-2
	Pyrene	129-00-0
	1,2,4,5-Tetrachlorobenzene	95-94-3
	2,3,4,6-Tetrachlorophenol	58-90-2

Appendix C: Summary of Constituents Included in Analyses - PCB Aroclors		
Method (Matrix)	**Chemical Name**	**CAS Number**
8082A (AQ and SO)	Aroclor-1016	12674-11-2
	Aroclor-1221	11104-28-2
	Aroclor-1232	11141-16-5
	Aroclor-1242	53469-21-9
	Aroclor-1248	12672-29-6
	Aroclor-1254	11097-69-1
	Aroclor-1260	11096-82-5
	Aroclor-1262	37324-23-5
	Aroclor-1268	11100-14-4

Appendix C: Summary of Constituents Included in Analyses - TCL Pesticides		
Method (Matrix)	**Chemical Name**	**CAS Number**
8081B (AQ and SO)	alpha-BHC	319-84-6
	beta-BHC	319-85-7
	delta-BHC	319-86-8
	gamma-BHC (Lindane)	58-89-9
	Heptachlor	76-44-8
	Aldrin	309-00-2
	Heptachlor epoxide	1024-57-3
	Endosulfan I	959-98-8
	Dieldrin	60-57-1
	4,4'-DDE	72-55-9
	Endrin	72-20-8
	Endosulfan II	33213-65-9
	4,4'-DDD	72-54-8
	Endosulfan sulfate	1031-07-8
	4,4'-DDT	50-29-3
	Methoxychlor	72-43-5
	Endrin ketone	53494-70-5
	Endrin aldehyde	7421-93-4
	cis-Chlordane (alpha-Chlordane)	5103-71-9
	trans-Chlordane (gamma-Chlordane)	5103-74-2
	Toxaphene	8001-35-2

Appendix C: Summary of Constituents Included in Analyses - TAL Metals and Cyanide		
Method(s) (Matrix)	**Chemical Name**	**CAS Number**
6010C/D, 6020B (SO and AQ)	Aluminum	7429-90-5
	Antimony	7440-36-0
	Arsenic	7440-38-2
	Barium	7440-39-3
	Beryllium	7440-41-7
	Cadmium	7440-43-9
	Calcium	7440-70-2
	Chromium	7440-47-3
	Cobalt	7440-48-4
	Copper	7440-50-8
	Iron	7439-89-6
	Lead	7439-92-1
	Magnesium	7439-95-4
	Manganese	7439-96-5
	Nickel	7440-02-0
	Potassium	7440-09-7
	Selenium	7782-49-2
	Silver	7440-22-4
	Sodium	7440-23-5
	Thallium	7440-28-0
	Vanadium	7440-62-2
	Zinc	7440-66-6
7470A (AQ) 7471B (SO)	Mercury	7439-97-6
9012B (AQ and SO)	Cyanide	57-12-5

Appendix D
Field Forms

Field Audit Form

Project: Site Location: Auditor:
1. Was project-specific training held?
2. Are copies of project plan on site and available to personnel?
3. Are samples being collected in accordance with the project plan?
4. Do the numbers and locations of samples conform to the project plan?
5. Are sample locations flagged, staked, or otherwise marked?
6. Are samples labeled in accordance with the project plan?
7. Is equipment decontamination in accordance with the project plan?
8. Is field instrumentation being operated and calibrated in accordance with the project plan?
9. Are samples being preserved and containerized in accordance with the project plan?
10. Are QC samples in accordance with the types, collection procedures, and frequencies specified in the project plan?
11. Are chain-of-custody procedures and documents in conformance with the project plan?
12. Are field records complete, accurate, up-to-date, and in conformance to good record keeping procedures?
13. Are modifications to the project plan being communicated, approved, and documented appropriately?
Additional Comments:

Auditor:	Date:

Date: ________________

AIR MONITORING FORM

Project Name: ____

Project Number: ____ Instrument: ____________________

Recorded by: ____ Calibration Date: ________________

Weather Conditions: ____

Time	Location	Wind Speed and Direction	Reading	Observations

Recording Procedures/Remarks: ____

____

____

____

TRC

AIR / VAPOR SAMPLE LOG

PROJECT NAME:		PREPARED		CHECKED	
PROJECT NUMBER:		BY:	DATE:	BY:	DATE:

SAMPLE INFORMATION				
SAMPLE TYPE:	COMPOSITE	GRAB	**SAMPLE ID:**	
SAMPLE MEDIA	INDOOR AIR SYSTEM PERFORMANCE OTHER	SOIL VAPOR	LOCATION:	LOCATION COORDINATES: N: E:
SAMPLE DURATION:			SAMPLE HEIGHT / (DEPTH):	
SAMPLE CONTAINER TYPE:	SUMMA CANISTER	TEDLAR BAG	OTHER:	
FLOW VALVE ID / SERIAL NUMBER:			CANISTER SERIAL NUMBER:	

READING	TIME	VACUUM (INCHES - Hg / PSIG)	DATE	INITIALS	COMMENTS
INITIAL VACUUM CHECK					
INITIAL FIELD VACUUM					
FINAL FIELD VACUUM					

SAMPLE START TIME:	SAMPLE STOP TIME:

NOTES AND OBSERVATIONS

MOTORIZED VEHICLE STORAGE :

MOTORIZED VEHICLE TRAFFIC:

OPERATIONS (e.g., painting, oil recovery):

CLEANERS / SOLVENTS IN USE:

MATERIAL STORAGE (e.g., paint, gasoline):

NOTICEABLE ODORS:

AUDIBLE OR NEARBY HVAC OPERATION:

OTHER:

ADDITIONAL COMMENTS:

SHIPPING METHOD: ____________	DATE SHIPPED: ____________	AIRBILL NUMBER: ____________
COC NUMBER: ____________	SIGNATURE: ____________	DATE SIGNED: ____________

TRC		**DATE:** **REPORT NO.:** **PAGE NO.:** 1 of 2 **PROJECT NO.:** **LOGBOOK NO.:** -- **PAGES:** -- to --

DAILY FIELD ACTIVITY REPORT

PROJECT ____________________

LOCATION ____________________

ATTACHMENTS ____________________

WEATHER	TIME	TEMP.	PRECIP.	WIND (MPH)	WIND (DIR)
		°F			
		°F			

SITE CONDITIONS:

WORK GOAL FOR DAY:

PERSONNEL ON SITE:

NAME	AFFILIATION	ARRIVAL TIME	DEPART TIME

EQUIPMENT ON SITE:

TYPE	MODEL	TYPE	MODEL

HEALTH & SAFETY:

PPE REQUIRED: ☒ LEVEL D ☐ LEVEL C ☐ LEVEL B ☐ LEVEL A **HASP?** YES

SITE SAFETY OFFICER:

H & S NOTES:

		DATE:
		REPORT NO.:
		PAGE NO.: 2 of 2
		PROJECT NO.:
		LOGBOOK NO.: -- **PAGES:** -- to --

DAILY FIELD ACTIVITY REPORT

DESCRIPTION OF WORK PERFORMED AND OBSERVED

PREPARED BY (OBSERVER):	**REVIEWED BY:**
PRINT NAME:	**PRINT NAME:**

FIELD CHANGE FORM

Project Name:____

Project Number:____________________Field Change Number:________________

Location: ______________________________Date:________________

Field Activity Description:____

Reason for Change:____

Recommended Disposition:____

____ ________________

Field Operations Officer (TRC) (Signature) Date

Disposition:____

____ ________________

On-site Supervisor (NYSDEC) (Signature) Date

Distribution: Project Manager (TRC)
Project Manager (NYSDEC)
Field Operations Officer (TRC)
On-site Supervisor (NYSDEC)

Others as Required:________________

TRC

GROUNDWATER SAMPLE LOG

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:		WELL DIAMETER:	2"	4"	6"	OTHER	____________
WELL MATERIAL:	PVC	SS	IRON	GALVANIZED STEEL		OTHER	____________
SAMPLE TYPE:	GW	WW	SW	DI	LEACHATE	OTHER	____________

PURGING | TIME: | DATE:

PURGE METHOD: PUMP ____________ BAILER ____________

DEPTH TO WATER: ________ T/ PVC

DEPTH TO BOTTOM: ________ T/ PVC

PUMP INTAKE DEPTH: ______ T/ PVC

FLOW-THRU CELL VOLUME ________ LITERS

WELL VOLUME: ________ LITERS GALLONS

VOLUME REMOVED: ________ LITERS GALLONS

COLOR: ____________ ODOR: ________

TURBIDITY

NONE SLIGHT MODERATE VERY

DISPOSAL METHOD: GROUND DRUM OTHER

SAMPLE | TIME: | DATE:

PH: ________ SU | CONDUCTIVITY: ________ umhos/cm

ORP: ________ mV | DO: ________ mg/L

TURBIDITY: ________ NTU

NONE SLIGHT MODERATE VERY

TEMPERATURE: ________ °C | OTHER: ____________

COLOR: ____________ | ODOR: ____________

FILTRATE (0.45 um) YES NO

FILTRATE COLOR: ____________ | FILTRATE ODOR: ____________

QC SAMPLE: MS/MSD DUP- ________

COMMENTS:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED | PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - _______

NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED		NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	
				Y	N					Y	N
				Y	N					Y	N
				Y	N					Y	N
				Y	N					Y	N

SHIPPING METHOD: ____________	DATE SHIPPED: ____________	AIRBILL NUMBER: ____________
COC NUMBER: ____________	SIGNATURE: ____________	DATE SIGNED: ____________

WATER SAMPLE LOG

(CONTINUED FROM PREVIOUS PAGE)

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)

SIGNATURE: ______________________________ DATE SIGNED: ______________________________

LOW FLOW GROUNDWATER SAMPLING LOG

PROJECT NAME		LOCATION ID	DATE
PROJECT NUMBER		START TIME	END TIME
SAMPLE ID	SAMPLE TIME	SITE NAME/NUMBER	PAGE OF

WELL DIAMETER (INCHES) ☐ 1 ☐ 2 ☐ 4 ☐ 6 ☐ 8 ☐ OTHER ______

TUBING ID (INCHES) ☐ 1/8 ☐ 1/4 ☐ 3/8 ☐ 1/2 ☐ 5/8 ☐ OTHER ______

MEASUREMENT POINT (MP) ☐ TOP OF RISER (TOR) ☐ TOP OF CASING (TOC) ☐ OTHER ______

WELL INTEGRITY	YES	NO	N/A
CAP	___	___	___
CASING	___	___	___
LOCKED	___	___	___
COLLAR	___	___	___

INITIAL DTW (BMP)	FT	FINAL DTW (BMP)	FT	PROT. CASING STICKUP (AGS)	FT	TOC/TOR DIFFERENCE	- FT
WELL DEPTH (BMP)	FT	SCREEN LENGTH	FT	PID AMBIENT AIR	PPM	REFILL TIMER SETTING	- SEC
WATER COLUMN	FT	DRAWDOWN VOLUME (final DTW - initial DTW X well diam. squared X 0.041)	GAL	PID WELL MOUTH	PPM	DISCHARGE TIMER SETTING	- SEC
CALCULATED GAL/VOL (column X well diameter squared X 0.041)	GAL	TOTAL VOL. PURGED (mL per minute X total minutes X 0.00026 gal/mL)	GAL	DRAWDOWN/ TOTAL PURGED		PRESSURE TO PUMP	- PSI

FIELD PARAMETERS WITH PROGRAM STABILIZATION CRITERIA (AS LISTED IN THE QAPP)

TIME 3-5 Minutes	DTW (FT) 0.0-0.33 ft Drawdown	PURGE RATE (mL/min)	TEMP. (°C) (+/- 3 degrees)	SP. CONDUCTANCE (mS/cm) (+/- 3%)	pH (units) (+/- 0.1 units)	DISS. O_2 (mg/L) (+/- 10%)	TURBIDITY (ntu) (+/- 10% <10 ntu)	REDOX (mv) (+/- 10 mv)	PUMP INTAKE DEPTH (ft)	COMMENTS
	BEGIN PURGING									

FINAL STABILIZED FIELD PARAMETERS (to appropriate significant figures[SF])

TEMP.: nearest degree (ex. 10.1 = 10)
COND.: 3 SF max (ex. 3333 = 3330, 0.696 = 0.696)
pH: nearest tenth (ex. 5.53 = 5.5)
DO: nearest tenth (ex. 3.51 = 3.5)
TURB: 3 SF max, nearest tenth (6.19 = 6.2, 101 = 101)
ORP: 2 SF (44.1 = 44, 191 = 190)

EQUIPMENT DOCUMENTATION

TYPE OF PUMP	DECON FLUIDS USED	TUBING/PUMP/BLADDER MATERIALS		EQUIPMENT USED
☐ PERISTALTIC	☐ LIQUINOX	☐ SILICON TUBING	☐ S. STEEL PUMP MATERIAL	☐ WL METER ______
☐ SUBMERSIBLE	X DEIONIZED WATER	☐ TEFLON TUBING	☐ PVC PUMP MATERIAL	☐ PID ______
☐ BLADDER	☐ POTABLE WATER	☐ TEFLON LINED TUBING	☐ GEOPROBE SCREEN	☐ WQ METER ______
______	☐ NITRIC ACID	☐ HDPE TUBING	☐ TEFLON BLADDER	☐ TURB. METER ______
☐ WATTERA	☐ HEXANE	☐ LDPE TUBING	☐ OTHER ______	☐ PUMP ______
☐ OTHER ______	☐ METHANOL	☐ OTHER ______	☐ OTHER ______	☐ OTHER ______
☐ OTHER ______	X OTHER ALCONOX	☐ OTHER ______	☐ OTHER ______	☐ FILTERS NO. ___ TYPE ______

ANALYTICAL PARAMETERS

	PARAMETER	METHOD NUMBER	FIELD FILTERED	PRESERVATION METHOD	VOLUME REQUIRED	SAMPLE COLLECTED	QC COLLECTED	SAMPLE BOTTLE ID NUMBERS
☐								
☐								
☐								
☐								
☐								
☐								
☐								

PURGE OBSERVATIONS

PURGE WATER CONTAINERIZED YES ☐ NO ☐ NUMBER OF GALLONS GENERATED ______

NO-PURGE METHOD UTILIZED YES ☐ NO ☐ If yes, purged approximately 1 standing volume prior to sampling or ________mL for this sample location.

SKETCH/NOTES

Sampler Signature: Print Name:

Checked By: Date:

Residential Well Sampling Log

Project:	**Project Number:**
Address of Residence:	**Sample ID:**
Homeowner's Name:	**Date:**
Contact Number:	**Sample Time:**
	Sampler's Name:

Description of Sample Location ***(circle one)*** **:**

System Bypass　　Exterior Faucet　　Kitchen/Bath Faucet

Sketch of Sample Location

Expansion Tank and Upstream Pipe Capacity

Tank Capacity (gallons) = ________

Tank Capacity (gallons) - if not stamped on tank = (radius of tank [ft]^2*height of tank [ft])* 23.5

Pipe Capacity (gallons) = ________

Pipe Capacity (gallons) = (radius of pipe [ft]^2* length of pipe upstream of tank [ft])* 23.5

Required Purge Volume: __________ (gallons)

Actual Purge Volume Prior to Sampling: _______(gallons)

Purge Time Duration: ________ (min)

Flow Rate During Sampling: ______________ (gpm)

Well Used in Past 24 Hours? ***(circle one)***

Yes　No　Unknown

Faucet Aerator present?　Yes　No

Faucet Aerator removed prior to sampling?　Yes　No

Field Parameters (If Applicable)

Time										
Temp (°C)										
Conduct. (umhos/cm)										
DO (mg/L)										
pH (std units)										
ORP (millivolts)										
Turbidity (NTU)										
Volume purged (gal)										
Flow Rate (ml/min)										

Laboratory Analysis

Analytical Parameter	**Filtered? Y N**	**Preservation**	**pH Chk**	**Volume**	**# of Bottles**

Notes: (age, type [drilled/dug], well depth, well yield, water treatment system type, where applicable)

QC Sample (Field Duplicate or MS/MSD) Collected?

SOIL BORING LOG

TRC	Project Name:		Boring ID:
	Project Location:		Page No.
	Project No.:	Client:	of:
Boring Location:	Refusal Depth:	Total Depth:	Bore Hole ID/OD:
Weather:	Soil Drilled:	Method:	Casing Size:
Subcontractor:		Protection Level:	Sampler:
Driller:	Date Started:	Date Completed:	Sampler ID/OD:
Rig Type/Model:	Logged By:	Checked By:	Latitude:
Reference Elevation:	Water Level:	Time:	Longitude:

Sample Information				Monitoring	Sample Description and Classification	USCS Group Symbol	Remarks
Depth (feet bgs) 0.0	Sample Number	Penetration/ Recovery (feet)	PID Reading (ppm)				

NOTES:

10 Maxwell Drive, Suite 200
Clifton Park, NY 12065

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Site Name: ______ Site Code: ______ Operable Unit: ______

Building Code: ______ Building Name: ______

Address: ______ Apt/Suite No: ______

City: ______ State: ______ Zip: ______ County: ______

Contact Information

Preparer's Name: ______ Phone No: ______

Preparer's Affiliation: ______ Company Code: ______

Purpose of Investigation: ______ Date of Inspection: ______

Contact Name: ______ Affiliation: ______

Phone No: ______ Alt. Phone No: ______ Email: ______

Number of Occupants (total): ______ Number of Children: ______

☐ Occupant Interviewed? ☐ Owner Occupied? ☐ Owner Interviewed?

Owner Name (if different): ______ Owner Phone: ______

Owner Mailing Address: ______

Building Details

Bldg Type (Res/Com/Ind/Mixed): ______ Bldg Size (S/M/L): ______

If Commercial or Industrial Facility, Select Operations: ______

If Residential Select Structure Type: ______

Number of Floors: ______ Approx. Year Construction: ______ ☐ Building Insulated? ☐ Attached Garage?

Describe Overall Building 'Tightness' and Airflows(e.g., results of smoke tests): ______

Foundation Description

Foundation Type: ______ Foundation Depth (bgs): ______ Unit: FEET

Foundation Floor Material: ______ Foundation Floor Thickness: ______

Foundation Wall Material: ______ Foundation Wall Thickness: ______ Unit: INCHES

☐ Floor penetrations? Describe Floor Penetrations: ______

☐ Wall penetrations? Describe Wall Penetrations: ______

Basement is: ______ Basement is: ______ ☐ Sumps/Drains? Water In Sump?: ______

Describe Foundation Condition (cracks, seepage, etc.) : ______

☐ Radon Mitigation System Installed? ☐ VOC Mitigation System Installed? ☐ Mitigation System On?

Heating / Cooling / Ventilation Systems

Heating System: ______ Heat Fuel Type: ______ ☐ Central A/C Present?

Vented Appliances

Water Heater Fuel Type: ______ Clothes Dryer Fuel Type: ______

Water Htr Vent Location: ______ Dryer Vent Location: ______

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

PRODUCT INVENTORY

Building Name: ______________________ Bldg Code: ______________ Date: ______________

Bldg Address: ______________________________________ Apt/Suite No: ______________

Bldg City/State/Zip: ______________________________________

Make and Model of PID: ______________________________ Date of Calibration: ______________

Location	Product Name/Description	Size (oz)	Condition *	Chemical Ingredients	PID Reading	COC Y/N?
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐
						☐

* Describe the condition of the product containers as **Unopened (UO)**, **Used (U)**, or **Deteriorated (D)**

** Photographs of the **front and back** of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

Product Inventory Complete? ☐ Were there any elevated PID readings taken on site? ☐ ☐ Products with COC?

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Site Name: ____________________ Site Code: __________ Operable Unit: __________

Building Code: ____________________ Building Name: ____________________

Address: ____________________ Apt/Suite No: __________

City: ____________________ State: ______ Zip: ______ County: __________

Factors Affecting Indoor Air Quailty

Frequency Basement/Lowest Level is Occupied?: [ ] Floor Material: [ ]

☐ Inhabited? ☐ HVAC System On? ☐ Bathroom Exhaust Fan? ☐ Kitchen Exhaust Fan?

Alternate Heat Source: [ ] ☐ Is there smoking in the building?

☐ Air Fresheners? Description/Location of Air Freshener: ____________________

☐ Cleaning Products Used Recently?: Description of Cleaning Products: ____________________

☐ Cosmetic Products Used Recently?: Description of Cosmetic Products: ____________________

☐ New Carpet or Furniture? Location of New Carpet/Furniture: ____________________

☐ Recent Dry Cleaning? Location of Recently Dry Cleaned Fabrics: ____________________

☐ Recent Painting/Staining? Location of New Painting: ____________________

☐ Solvent or Chemical Odors? Describe Odors (if any): ____________________

☐ Do Any Occupants Use Solvents At Work? If So, List Solvents Used: ____________________

☐ Recent Pesticide/Rodenticide? Description of Last Use: ____________________

Describe Any Household Activities (chemical use,/storage, unvented appliances, hobbies, etc.) That May Affect Indoor Air Quality:

☐ Any Prior Testing For Radon? If So, When?: ____________________

☐ Any Prior Testing For VOCs? If So, When?: ____________________

Sampling Conditions

Weather Conditions: [ ] Outdoor Temperature: [ ] °F

Current Building Use: [ ] Barometric Pressure: [ ] in(hg)

Product Inventory Complete? [ ] ☐ Building Questionnaire Completed?

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Building Code: ______________________ Address: ______________________

Sampling Information

Sampler Name(s): ______________________ Sampler Company Code: ______________________

Sample Collection Date: ______________________ Date Samples Sent To Lab: ______________________

Sample Chain of Custody Number: ______________________ Outdoor Air Sample Location ID: ______________________

SUMMA Canister Information

Sample ID:					
Location Code:					
Location Type:					
Canister ID:					
Regulator ID:					
Matrix:					
Sampling Method:					

Sampling Area Info

Slab Thickness (inches):					
Sub-Slab Material:					
Sub-Slab Moisture:					
Seal Type:					
Seal Adequate?:	☐	☐	☐	☐	☐

Sample Times and Vacuum Readings

Sample Start Date/Time:					
Vacuum Gauge Start:					
Sample End Date/Time:					
Vacuum Gauge End:					
Sample Duration (hrs):					
Vacuum Gauge Unit:					

Sample QA / QC Readings

Vapor Port Purge:	☐	☐	☐	☐	☐
Purge PID Reading:					
Purge PID Unit:					
Tracer Test Pass:	☐	☐	☐	☐	☐

Sample start and end times should be entered using the following format: MM/DD/YYYY HH:MM

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

LOWEST BUILDING LEVEL LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the lowest building level .
The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sketc
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or F	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

FIRST FLOOR BUILDING LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the first floor of the building.
The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sket(
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or **F**	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

OUTDOOR PLOT LAYOUT SKETCH

Please click the box with the blue border below to upload a sketch of the outdoor plot of the building as well as the surrounding area. The sketch should be in a standard image format (.jpg, .png, .tiff)

Clear Image

Design Sketch

Design Sketch Guidelines and Recommended Symbology

- Identify and label the locations of all sub-slab, indoor air, and outdoor air samples on the layout sketch.
- Measure the distance of all sample locations from identifiable features, and include on the layout sketch.
- Identify room use (bedroom, living room, den, kitchen, etc.) on the layout sket(
- Identify the locations of the following features on the layout sketch, using the appropriate symbols:

B or F	Boiler or Furnace	o	Other floor or wall penetrations (label appropriately)
HW	Hot Water Heater	**xxxxxxx**	Perimeter Drains (draw inside or outside outer walls as appropriate)
FP	Fireplaces	**######**	Areas of broken-up concrete
WS	Wood Stoves	● SS-1	Location & label of sub-slab samples
W/D	Washer / Dryer	● IA-1	Location & label of indoor air samples
S	Sumps	● OA-1	Location & label of outdoor air samples
@	Floor Drains	● PFET-1	Location and label of any pressure field test holes.

Surface Water/Sediment Sample Log	Project:	Project No.:	Date/Time:	Sheet 1 of 1
	Contractor Personnel:		TRC Personnel:	

Sample No.:	**Sample Location:**
Depth/Interval Sampled:	**Sample Type: (circle)** Grab Composite Both
Field Screening Information:	**Media: (circle)** Other ___________ Sediment Surface Water **Water Depth:**
Other Field Observations:	**Sample Description/Observations:**

SAMPLE COLLECTION EQUIPMENT

Hand Auger	☐	Dip Sampler	☐
Core Sampler	☐	Trowel	☐
Spatula/Spoon	☐	Dredge Sampler	☐
Bowl (stainless)	☐	Kemmerer	☐
En-Core®	☐	Extension Rods	☐
Tube Auger	☐	Van Dorn Bottle	☐
Direct	☐	Spade	☐
Ponar Grab	☐	Shovel	☐
Bucket Auger	☐	Terra Core™	☐
Peristaltic Pump	☐	Scoop	☐
Macro-Core®	☐	Vibracore	☐
Other	☐	Split-spoon	☐

Analytical Parameters	Preservation Method	Volume/Container	Time of Collection	Sample ID

Signed: ________________________________

Test Pit Log

TRC	Project Name/Number:	Test Pit Number: Sheet___ of ___
	Location:	Date/Time
Equipment Used (e.g., reach/capacity):	Contractor Personnel:	TRC Personnel:
Total Depth:	Contractor Used:	Top of Pit Elevation:
Depth to Ground Water:	Weather:	

Depth	Sample Number	Stratigraphic Description	REMARKS
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

TEST PIT PLAN

North

Vol = ____ cu. yd.

PROPORTIONS

BURMISTER USED

Trace (TR)	0-10%
Little (LI)	10-20%
Some (SO)	20-35%
And	35-50%

USCS USED

Trace (TR)	<5%
Few	5-10%
Little (LI)	15-25%
Some (SO)	30-45%
Mostly (MO)	>50%

GRAIN SIZE (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
e. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Comments: ______________________________

____

____

____

____

Rev: October 2014

WATER AND PRODUCT LEVEL MONITORING FORM

Technician: ________________ **Job #/Task #:** ____________________ **Date:** ________________

Site # ________________ **Project Manager** ____________________ **Page** _____ **of** _______

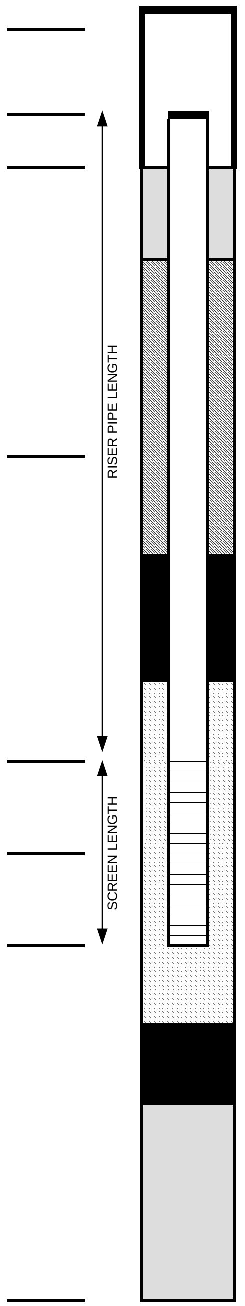
Well #	TOC	Time Gauged	Total Depth (feet)	Depth to Water (feet)	Depth to Product (feet)	Product Thickness (feet)	Time Sampled	Misc. Well Notes

FIELD DATA COMPLETE	QA/QC	COC	WELL BOX CONDITION SHEETS
MANIFEST	DRUM INVENTORY	TRAFFIC CONTROL	

WELL CONSTRUCTION DIAGRAM (FLUSH-MOUNT)

PROJ. NAME:		WELL ID:	
PROJ. NO:	DATE INSTALLED: INSTALLED BY:		CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



0.0 GROUND SURFACE

TOP OF CASING

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________________

PIPE SCHEDULE: ____________________

PIPE JOINTS: ____________________

SCREEN TYPE: ____________________

SCR. SLOT SIZE: ________

BOREHOLE DIAMETER: _____ IN. FROM _____ TO _____ FT.
_____ IN. FROM _____ TO _____ FT.

SURF. CASING DIAMETER: _____ IN. FROM _____ TO _____ FT.
_____ IN. FROM _____ TO _____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________________

TIME DEVELOPING: _____ HOURS

WATER REMOVED: _____ GALLONS

WATER ADDED: _____ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________________

COLOR BEFORE: ____________________

CLARITY AFTER: ____________________

COLOR AFTER: ____________________

ODOR (IF PRESENT): ____________________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

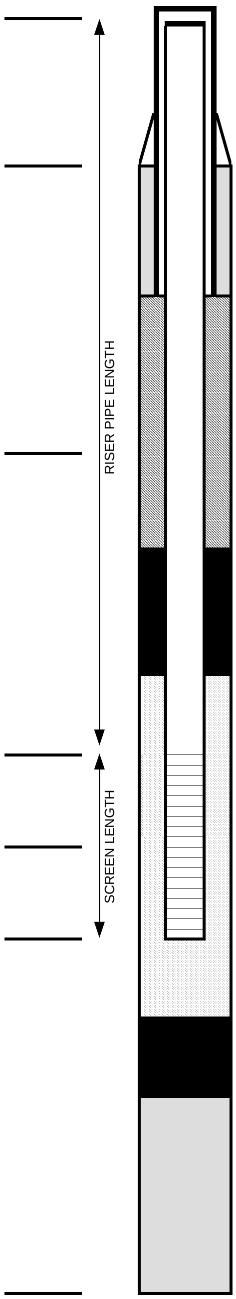
PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

LOCK KEY NUMBER: ________

WELL CONSTRUCTION DIAGRAM (ABOVE-GRADE)

PROJ. NAME:		WELL ID:	
PROJ. NO:	DATE INSTALLED: INSTALLED BY:	CHECKED BY:	

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



TOP OF CASING

0.0 GROUND SURFACE

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________

PIPE SCHEDULE: ____________

PIPE JOINTS: ____________

SCREEN TYPE: ____________

SCR. SLOT SIZE: ______

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________

TIME DEVELOPING: ____ HOURS

WATER REMOVED: ____ GALLONS

WATER ADDED: ____ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________

COLOR BEFORE: ____________

CLARITY AFTER: ____________

COLOR AFTER: ____________

ODOR (IF PRESENT): ____________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

LOCK KEY NUMBER: ____________

FIGURE 3

WELL DECOMMISSIONING RECORD

Site Name:	Well I.D.:
Site Location:	Driller:
Drilling Co.:	Inspector:
	Date:

DECOMMISSIONING DATA
(Fill in all that apply)

<u>OVERDRILLING</u>

Interval Drilled	
Drilling Method(s)	
Borehole Dia. (in.)	
Temporary Casing Installed? (y/n)	
Depth temporary casing installed	
Casing type/dia. (in.)	
Method of installing	

<u>CASING PULLING</u>

Method employed	
Casing retrieved (feet)	
Casing type/dia. (in)	

<u>CASING PERFORATING</u>

Equipment used	
Number of perforations/foot	
Size of perforations	
Interval perforated	

<u>GROUTING</u>

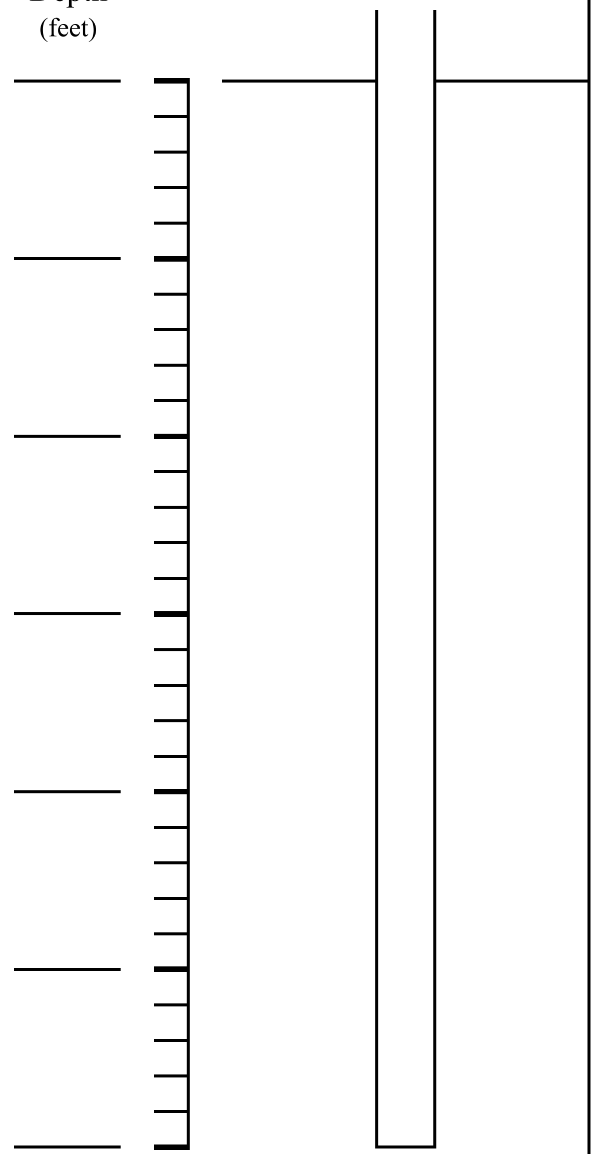
Interval grouted (FBLS)	
# of batches prepared	

<u>For each batch record:</u>

Quantity of water used (gal.)	
Quantity of cement used (lbs.)	
Cement type	
Quantity of bentonite used (lbs.)	
Quantity of calcium chloride used (lbs.)	
Volume of grout prepared (gal.)	
Volume of grout used (gal.)	

WELL SCHEMATIC*

Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

TRC Results you can rely on

Well Development Form

Project:	Project No.:	Date/Time:	Sheet ___ of ___
TRC Personnel:			

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Protective Casing Stick-up (from ground) ________ ft.

Riser Stick-up (from ground) ________ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ _____

Well Depth ____ ft. ☐ top of riser ☐ top of casing ☐ ___________ ☐ measured ☐ historical

Water Depth ____ ft.

Height of Water Column ____ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

______ Total gallons purged

[Vol. = r^2 h(0.163)]

PID SCREENING MEAS.

Background	
Well Mouth	

WELL MATERIAL

☐ PVC ☐ SS ☐ ___

FIELD WATER QUALITY MEASUREMENTS

Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (μmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									
Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (μmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									

EQUIPMENT USED:

NOTES/COMMENTS:

Signed:______________________________

Appendix E

TRC SOP ECR023 – Packaging and Shipping of Non-Hazardous Environmental Samples

Title: **Packaging and Shipping of Non-Hazardous Environmental Samples**	Procedure Number: **SOP Fact Sheet ECR 023**
	Revision Number: **0**
	Effective Date: **January 2018**

Darby Litz		Elizabeth Denly	
Technical Reviewer	Date	ECR Practice Quality Coordinator	Date
Darby Litz	01/11/18	Elizabeth Denly	01/11/18

SOP FACT SHEET

PACKAGING AND SHIPPING OF NON-HAZARDOUS ENVIRONMENTAL SAMPLES

Purpose and Objective

This fact sheet has been developed to guide TRC personnel in the methods for proper packaging and shipping of non-hazardous environmental samples. In general, non-hazardous environmental samples include drinking water, groundwater, ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with regulated levels of hazardous materials (dangerous goods). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as hazardous materials (see below). Please note that packaging of vapor and air samples is not included in this SOP Fact Sheet. Proper packaging and shipping of samples is important for maintaining sample integrity and ensuring prompt and reliable shipment of the samples to the analytical laboratory, as well as protecting the health and safety of the field, shipping, and laboratory personnel.

This Fact Sheet **does not address the shipment of hazardous materials**, as the shipping of hazardous materials requires specialized packaging, labeling, shipping, and training/certification. **Note**: According to the United States Department of Transportation, "the Secretary shall designate material (including an explosive, radioactive material, infectious substance, flammable or combustible liquid, solid, or gas, toxic, oxidizing, or corrosive material, and compressed gas) or a group or class of material as hazardous when the Secretary determines that transporting the material in commerce in a particular amount and form may pose an unreasonable risk to health and safety or property" 49 U.S.C 5103(a). If the composition and properties of a waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport. In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., nitric acid [HNO_3], sodium hydroxide [NaOH] pellets, hydrochloric acid [HCl], Methanol, etc.), which are designated as dangerous goods by the International Air Transport Association (IATA), is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance. Dangerous goods must not be offered for air transport by any personnel except personnel trained and certified by IATA in dangerous goods shipment. Contact the laboratory if you are unsure if your material is regulated or need assistance in shipping or transporting samples.

What to Bring (some or all of these may apply)

- Appropriate level of personal protection in accordance with the Site Health and Safety Plan
- Coolers with return address of TRC office written on inside of lid or coolers provided by laboratory
- Heavy-duty plastic bags and/or trash bags
- Plastic Ziploc® bags, small and large
- Fiberglass-reinforced packing tape or strapping tape is preferred, or clear packing tape or duct tape
- Packing materials, such as foam peanuts and/or Bubble Wrap®

- Ice (Blue ice not recommended)
- Custody seals
- Chain-of-custody forms
- Landing pad (can be purchased from Federal Express; see Attachment)
- Tie-on tags (can be purchased from Federal Express; see Attachment)
- Shipping labels and documents (*e.g.*, air bill)
- Pens and markers, preferably waterproof
- Zip ties
- Clear tape
- Cooler labels ("Keep Refrigerated/Cool", "THIS END UP", "FRAGILE", "Saturday delivery", arrow labels, etc.)
- Laboratory-prepared temperature blank

<u>On-site Procedures</u>

- Use a sturdy cooler in good condition. Secure and tape drain plug (inside and outside), if present, with fiberglass-reinforced packing tape or duct tape.
- Line the cooler with a large heavy-duty plastic/trash bag.
- Verify that all caps on bottles are tight (will not leak).
- Verify sample labels and chain-of-custody records are completed properly.
- Pack samples with sufficient padding and ice to remain intact during shipment and at proper preservation temperature.
- If glass bottles are being shipped, place a layer of shock-absorbent material, such as Bubble Wrap®, on the base of the cooler to protect against breakage during shipping. Additionally, considered placing shock-absorbent material between the sample containers and the cooler sidewalls.
- Consider placing all bottles in separate and appropriately sized plastic Ziploc® bags or Bubble Wrap® bags provided by the laboratory. Up to three volatile organic analysis (VOA) vials may be packed in one Bubble Wrap® bag (from the same sample point). All glass bottles should be wrapped in Bubble Wrap®; all sample bottles should be placed in the cooler in a vertical position to minimize potential leaks and cross-contamination.
- Verify appropriate trip blanks (for volatile organic compound [VOC] analyses) and temperature blanks are included in the sample cooler in accordance with project-specific requirements. If multiple coolers prepared for one project, keep VOC samples in the same cooler to minimize the number of trip blanks submitted for analysis.
- Place ice in cooler. A plastic bag should be used as a moisture barrier between the ice and sample bottle labels to protect label integrity. This can be accomplished by placing loose ice around sealed Ziploc® bags containing sample bottles or by sealing ice in large plastic Ziploc® bags or trash bags and placing around the sample containers. Ice should be below, in between, and on top of samples within the large heavy-duty plastic/trash bag. **NOTE:** It is recommended that at least one-third of the cooler volume should be filled with ice.

- Fill the remaining space in cooler with shock-absorbent material, such as sheets of Bubble Wrap®. Keep in mind that the sample containers are less likely to break if their movement is minimized during shipment.
- Place the completed chain-of-custody record for the laboratory in a plastic Ziploc® bag. Tape the bag to the inner side of the cooler's lid. **NOTE:** If laboratory courier service is used, the chain-of-custody record may be handed to the courier and not be put inside the cooler; the courier must sign the record upon receiving the samples. Alternately, you can treat the laboratory courier just as you would a common carrier like Federal Express. In this situation, the chain-of-custody gets signed at the laboratory upon receipt.
- The sampler should keep a copy of the completed and signed chain-of-custody record.
- Wrap cooler at least two times with fiberglass-reinforced packing tape (preferred) or duct tape at each end of the cooler.
- Custody seals should be placed on the opening of the cooler. **NOTE:** Custody seals are not required when laboratory courier service is used, as long as the courier signs the chain-of-custody document as noted above. Consider applying custody seals even on hand-delivered or couriered coolers to avoid potential confusion. Cover the custody seal with clear packing tape that extends around the entire cooler and overlaps itself so that it cannot be easily removed without breaking the seal. In some situations, it may be appropriate to install two (or more) custody seals, one at each end, placed diagonally opposite from one another. The custody seals should be placed such that the cooler cannot be opened without destroying at least one of the labels.
- Use a "THIS END UP" label or arrow labels to indicate proper upward position of the container.
- Add a label containing name and address of both the shipper and the recipient on the outside of the container. Use Federal Express tie-on tags, if applicable, attached with zip ties to affix the label to the cooler handle if possible.

<u>Shipping</u>

- Consider using prepaid shipping labels supplied by the laboratory, if possible.
- Determine ahead of time the location and deadline for when samples must be available for courier pickup or at the shipper to ensure the samples go out on time.
- Ship the sample using an appropriate method, typically overnight or same day, to arrive by the required time. Samples shipped on Friday for Saturday delivery must be coordinated ahead of time to verify laboratory staff are available to receive the samples on weekends. Liberally apply "Saturday Delivery" stickers to the outside of the cooler. Verify that the common carrier marks the cooler and shipping documents appropriately for Saturday or Sunday delivery.
- Check the laboratory sample tracking for acknowledgment of receipt of container and arrival of shipment.

Additional Guidelines when Using Federal Express

A. Shipping Coolers with Environmental Samples by Federal Express (FedEx)

TRC has experienced some issues with coolers not getting to their destination because of lost labels and this has resulted in the recollection of samples. Shipping of coolers presents a unique problem. It is important that the contents of coolers arrive at the laboratory in a timely manner, but sometimes, despite best efforts, the shipping labels come off of the coolers because they do not adhere well. This may cause delays and/or non-delivery of the coolers, resulting in samples that are no longer available or not appropriate for analysis because of temperature and/or holding time requirements.

At the advice of FedEx, it is strongly recommended that every time a cooler is shipped, that **two** different types of labels be used on the cooler:

1. A “landing pad” (FedEx #156841): A “landing pad” is a super sticky label that is adhered directly to the top of the cooler. The barcode label then gets put on top of the landing pad. These landing pads are designed specifically for use with odd-shaped or non-smooth surfaces.
2. A “tie-on tag” (FedEx #150454 large tag, or #149849 for small tag): Along with the landing pad and label, it was recommended to also use a tie-on tag if there is a handle on the cooler. The tie-on tag wraps around the handle of the cooler and then sticks to itself. The barcode label then gets adhered to the longer side of the tie-on tag. For added strength, a zip-tie should also be used to secure the tie-on tag to the handle.

Both the landing pads and the tie-on tags can be ordered by calling 800.GoFedEx and referring to the FedEx #s above. In addition:

1. TRC staff should place these labels on the coolers, rather than having FedEx place them.
2. TRC staff should place a “Keep Refrigerated/Cool” label on the cooler, which may be helpful to keep the shipment moving.
3. The use of laboratory courier service, when available, rather than FedEx, is suggested.

B. Insuring Sample Shipments

FedEx does NOT insure sample shipments; meaning if the shipment is lost or delayed, FedEx will not pay for the cost to recollect the samples.

What FedEx does offer is a Declared Value; however, again this does not cover the cost to recollect the samples. Therefore, do **NOT** pay the extra fee for a Declared Value when shipping a cooler of samples; it is a waste of money.

What may be available is that TRC’s insurance program may cover losses in excess of $10,000. If you have an incident that meets these criteria, you should notify your manager, Greg Hobbs and Andrew Johnson/TRC legal for any loss you believe exceeds $10,000. TRC legal can address the merits of an insurance claim at that point in time.

C. Insuring Equipment Shipments

When shipping equipment (e.g., a GPS unit), the following is suggested:

1. Using FedEx's Declared Value option **DOES** make sense when shipping valuable equipment. Currently FedEx's cost for this option is $3 for shipments valued between $100 to $300, and $1 per $100 of declared value for shipments in excess of $300. The cost of insuring equipment should be factored into the cost of the project.
2. If the equipment does not have its own specialized shipping container (e.g., pelican case), then request that FedEx package the equipment for shipment. If FedEx provides the packaging, and the equipment is damaged, then FedEx is responsible. If TRC packages the equipment, then experience has shown that FedEx will deny the claim, even if a Declared Value was used, because FedEx will claim that it was improperly packaged.

Appendix F
TRC SOP CP0028 – Preventative Maintenance Program

1. PURPOSE

The purpose of this program is to establish the responsibilities and process for maintaining equipment used at field project sites in good working condition to reduce the risk of injuries to personnel.

2. SCOPE

This program applies to field project where equipment is used that could increase the risk of injury to personnel if the equipment is not proactively maintained. The program does not supersede any existing preventive maintenance requirements set forth by equipment manufacturers or nationally recognized consensus standards. Where items are subject to preventive maintenance requirements under multiple programs, the more stringent program/requirement shall apply.

3. DEFINITIONS

ANSI: Means the American National Standards Institute

API: Means the American Petroleum Institute

ASME: Means the American Society of Mechanical Engineers

NFPA: Means the National Fire Protection Association

OSHA: Means the Occupational Safety and Health Administration

Preventative Maintenance: Means systematic inspection, detection, correction, and prevention of incipient failures a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

4. RESPONSIBILITIES

4.1 The National Safety Director is responsible for communicating this program to affected employees.

4.2 TRC's Safety Network is responsible for providing guidance to Project Managers and Superiors on selecting appropriate safety precautions based on the project-specific risk factors.

4.3 Project Managers are responsible for the following

- Identifying equipment used at field project sites that needs to be included in the preventative maintenance program.

- Determining the preventative maintenance requirements and frequency for affected equipment.
- Assigning the responsibility of performing preventative maintenance tasks to TRC employees, or qualified contractor.
- Maintaining preventive maintenance schedules and the records of last maintenance inspections of equipment.
- Communicating the requirements of this program to affected subcontractors.

4.4 TRC Employees are responsible for the following:

- Conduct a visual inspection of equipment prior to use to ensure safety-related features are functioning properly.
- Immediately notify supervisors of facility/equipment failures and/or problems noted in visual inspections.
- Never use equipment that is not current with preventative maintenance, or is defective or damaged.

5. PROCEDURE

5.1 Equipment Assessment

- The Project Manager, in consultation with TRC's Safety Network, shall identify equipment that needs to undergo preventative maintenance. Preventative maintenance describes tasks that should be performed to maximize the life of equipment and also prevent unplanned equipment failures. Examples of tasks include, replacing critical components before they fail, lubricate equipment, inspect equipment and/or critical components. For reference, a list of safety related inspection requirements is listed in Appendix B – *"Equipment Inspection Requirements."*
- Preventative maintenance requirements should be identified by one or more of the following:
  - Manufacturer's recommendation
  - Regulatory requirement (i.e., OSHA)
  - National consensus standards (i.e., ANSI, ASME, NFPA, API, etc.)
  - Client requirements
  - TRC policy
- Equipment that typically has preventative maintenance requirements can include:
  - Portable fire extinguishers

- Overhead Lifting Equipment (i.e., hoists, cranes)
- Rigging Equipment (i.e., chains, slings, shackles, etc.)
- Emergency Equipment (sprinklers, fire alarms, emergency lighting, etc.)
- PPE (respirators, personal fall arrest devices, self-retracting lanyards, electrical gloves)
- Atmospheric Monitoring Equipment (i.e., 4-gas monitor)
- Powered and Portable Hand-tools
- Powered Industrial Vehicles (i.e., forklift, aerial lift, scissor lift, etc.)
- Electrical Protective Devices (i.e., insulated tools, GFCI's, etc.)

5.2 Scheduling and tracking.

- All equipment that is included in the preventative maintenance program shall be listed on Appendix A – "Preventive Maintenance Schedule." In addition, the maintenance task(s), frequency, the person responsible for completing the maintenance, completion date, and status must be listed on the schedule.
- Only competent and authorized employees or contractors shall perform preventative maintenance activities on equipment.

5.3 Damaged or defective equipment

- Equipment that is found to be damaged or defective, including early signs of wear or damage, shall be tagged as inoperable and removed from service.
- Damaged equipment can only be repaired by an authorized person.

6. REFERENCES/RELATED DOCUMENTATION

None

7. RECORDS

The completed preventative maintenance schedule shall remain with the project file for the duration of the project.

8. APPENDICES

Appendix A – Preventative Maintenance Schedule

Appendix B – Equipment Inspection Requirements

Appendix A
Preventative Maintenance Schedule

Project Name:		**Project Manager:**			**Project Start Date:**	
Equipment	**PM Tasks(s) (inspect, lubricate, replace part, etc.)**	**Responsible Person**	**Frequency (Daily, Monthly, Annual)**	**Reference**	**Completion Date**	**Equipment Status (Ok, Needs Repair)**
Portable Fire Extinguisher #2	*Visually inspect for accessibility, operable pressure, hose condition, fullness*	*Joe Foreman*	*30 days*	*NFPA 10 Chapter 7.2*	*December 15, 2015*	*OK*

Appendix B
Equipment Inspection Requirements

Equipment	Inspection Criteria	Frequency	Reference
Personal Fall Arrest Equipment	Personal fall arrest systems shall be inspected prior to each use	Prior to each use	29 CFR1926.502(d)(21)
Emergency lighting	Test the light to verify it remains functional	Monthly (30 second test); Annually (90 minute test)	National Fire Codes 101-31-1.3.8 as referenced by the OSHA standards
Cranes and hoists	All functional operating mechanisms for maladjustments (daily); – deteriorating or leaking lines, valves, etc., in air or hydraulic systems (daily); – deformation or cracks in hooks (daily visual inspection/monthly inspection with a certification record); – hoist chains, including end connections, for excessive wear, twist, distorted links, or stretch beyond manufacturer's recommendation (daily visual inspection/monthly inspection with a certification record); – all functional operating mechanisms for excessive wear; and – rope reeving for noncompliance with manufacturer's recommendations.	Daily	29 CFR 1910.179(j)(2)(i)
Slings and rigging equipment	Verify equipment is not damaged and required tags/labels are legible.	Daily	29 CFR 1910.184(d)
Forklift trucks	Visually inspect forklifts for damage or defects	Each Shift	1910.178(q)(7)
Lifting and support jacks	Visually inspect for damage or defects	Annually	29 CFR 1910.244(a)(2)(vi)
Lifting and support jacks	Lubricate as required	Regular intervals	29 CFR 1910.244(a)(2)(v)
Lifting and support jacks	For constant or intermittent use at one locality, visually inspect for damage or defects	Once every 6 months,	29 CFR 1910.244(a)(2)(vi)(a)
Portable power tools, extension cords, and power strips	Visually inspect for external defects (such as loose parts, deformed and missing pins, or damage to outer jacket or insulation) and for evidence of possible internal damage (such as pinched or crushed outer jacket).	Prior to use	29 CFR 1910.334(a)(2)(i)
Compressed gas cylinders	Visually inspect items such as markings, shell condition, oil, pressure relief device, valve, and label/color.	Upon receipt	49 CFR Parts 171-179 and 14 CFR Part 103; Compressed Gas Association pamphlet.

APPENDIX B
SITE-SPECIFIC HEALTH AND SAFETY PLAN

SITE-SPECIFIC HEALTH AND SAFETY PLAN

FARRAND CONTROLS
VALHALLA, NEW YORK 10595
NYSDEC Site No. 360046
Work Assignment No. D09812-30

Prepared for:
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, NY 12233

Prepared by:
TRC Engineers, Inc.
215 Greenfield Parkway, Suite 102
Liverpool, New York 13088

TRC Project No.: 489357.0000.0000

May 2023

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1. Site/Project Contact Information

Table 1 – Site/Project Contact Information			
Site Information			
Site Name	**Site No.**	**Address**	
Farrand Controls	360046	99 Wall Street, Valhalla, NY 10595	
Client Contact			
Name	**Organization**	**Title**	**Primary Phone No.**
Mark Domaracki	NYSDEC	Project Manager	(518) 402-9832
TRC Personnel and Project Role			
Name	**Role**	**Email**	**Primary Phone No.**
Michael Glenn	Health and Safety Officer (HSO)	mglenn@trccompanies.com	(949) 697-7418 (cell)
David Sullivan	Assistant HSO	dsullivan@trccompanies.com	(978) 758-2809 (cell)
James Magda	Contract Manager	jmagda@trccompanies.com	(315) 415-4315 (cell)
Derek Kaiding	Project Manager	dkaiding@trccompanies.com	(248) 462-4457 (cell)
Justin King	Project Management Support	jking@trccompanies.com	(518) 860-7656 (cell)
Jonathan Bone	Office Safety Coordinator (OSC)	jbone@trccompanies.com	(315) 436-0853 (cell)
TBD	On-Site HSO/Field Staff		
TBD	Field Staff		
Contractor Information			
Company Name	**Service**	**Primary Contact**	**Primary Phone No.**
GPRS, Inc.	Utility Locating	Tania Lovejoy	(929) 418-0069
Cascade Environmental	Drilling	Shawn Tibbetts	(516) 318-9182
Hager-Richter Geoscience, Inc.	Down-Hole Geophysics	Robert Garfield, P.G.	(609) 876-5083
Flexible Liner Underground Technologies	Hydrogeological characterization, NAPL/FACT analysis, multilevel well Installation	Daniel Schramm and/or "Carl"	(505) 852-0128
L.K. McLean Associates, P.C.	Land Surveying	Tamara Stillman, PLS	(631) 286-8668
Innovative Recycling Technologies, Inc.	IDW Handling, Transportation, and Disposal	Jack Ewen	(516) 816-4375
Eurofins Environment Testing Northeast, LLC	Analytical Laboratory	Anthony Massa	(315) 431-0171
Emergency Assistance			
Service	**Name**	**Emergency No.**	**Primary Phone No**
Ambulance	Valhalla Volunteer Ambulance Corps	911	(914) 946-8138

Emergency Assistance			
Service	**Name**	**Emergency No.**	**Primary Phone No**
Early Inc. Intervention	WorkCare	1-888-449-7787	Not applicable
Fire	Valhalla Fire Department	911	(914) 948-2272
Hospital	Westchester Medical Center	911	(914) 493-7307
Police	Mount Pleasant Police Department	911	(914) 769-1941
Poison Control Center	Upstate Medical Center	Not applicable	(800) 222-1222
Spill	CHEMTREC	Not applicable	1-800-424-9300 (TRC No. CCN 671126)
Spill (Federal)	National Response Center	1-800-424-8802	Not applicable
Spill (State)	New York State Spill Hotline	1-800-457-7362	Not applicable

2. Medical Facility Identification and Directions

Nearest Hospital: Westchester Medical Center

Hospital Address: 100 Woods Road, Valhalla, New York 10595

Hospital Telephone Number: (914) 493-7307

Directions to Hospital (see attached Map):

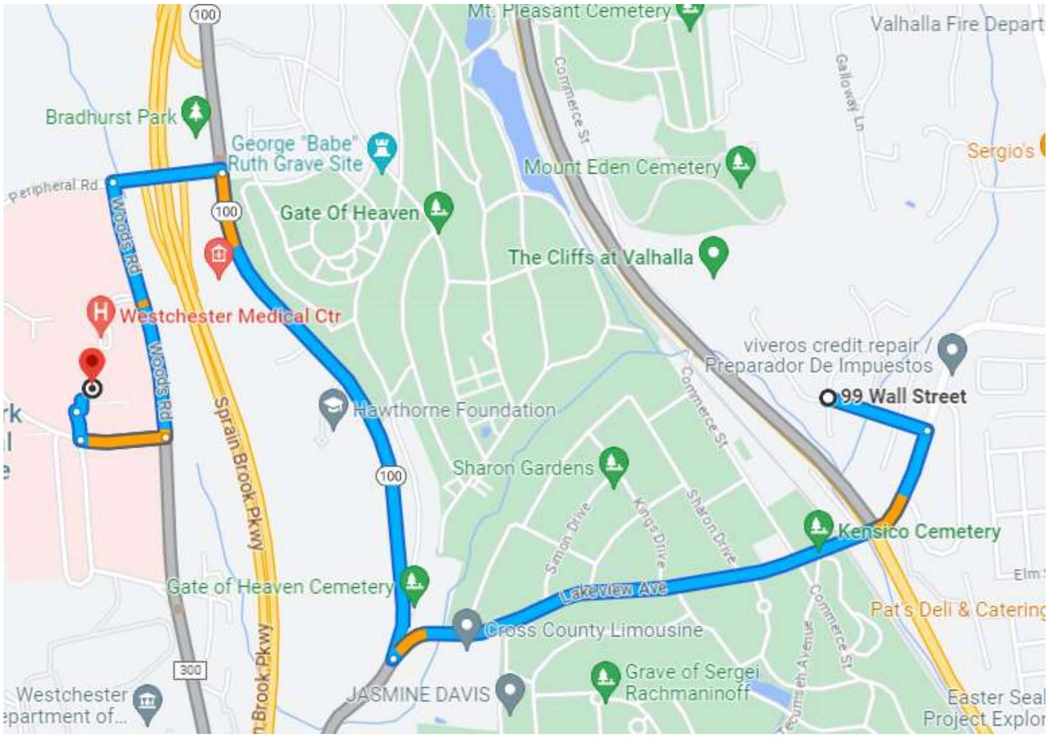
8 min (2.7 miles)
via Lakeview Ave and NY-100 N
Fastest route now due to traffic conditions

99 Wall St
Valhalla, NY 10595

- Head east on Wall St toward Grand Blvd
  57 sec (0.2 mi)
- Continue on Lakeview Ave. Take NY-100 N to Emergency Dr/Westchester Rd
  6 min (2.3 mi)
- Continue on Emergency Dr/Westchester Rd to your destination
  1 min (0.2 mi)

Westchester Medical Center Emergency Department
100 Woods Rd, Valhalla, NY 10595

Map to Hospital:



3. Utility Clearance

Dig Safely New York and non-member utilities will be notified at least 72 hours prior to commencing any ground intrusive work. Prior to the start of work, confirmation receipts will be reviewed, and utility mark-outs will be verified.

A private utility survey will be required to survey the proposed soil boring, monitoring well and test pit locations using at a minimum Ground Penetrating Radar (GPR) and Electro-Magnetic/Radio Frequency (EM/RF) Pipe, Cable and Box locator. The survey shall encompass an area extending in all directions at least 10 feet beyond each of the locations.

Any structure detected in the subsurface within 10 feet of the proposed soil boring, monitoring well and test pit locations will be identified on the ground surface with spray paint. Results of the utility survey will be reviewed in the field between TRC and the utility surveyor the same day the service is provided. Results will also be summarized in a brief utility survey report which shall be prepared by the utility surveyor and submitted to TRC. Additionally, all proposed locations will be hand-cleared prior to commencement of intrusive activities to confirm absence of underground utilities.

Prior to the operation of any heavy equipment, the site shall be inspected for potential overhead hazards (e.g., wires, tree branches, etc.). A minimum clearance of 10 feet must be maintained between equipment and overhead utility lines. If contact is possible (i.e., equipment, drill rig, excavator, etc.) one or more of the following will be done: 1) Power sources will be disconnected by the utility; 2) Power sources will be shielded by the utility; 3) Object will get no closer than 10 feet to prevent arcing, unless site specific conditions or weather conditions warrant greater separation per best professional judgment, or as directed by utility representatives; and, 4) Evaluate the need for shielding and coordinate with local utility representatives.

4. Scope of Work Summary

The scope of work outlined in this HASP covers tasks associated with a utility survey, video inspection of the stormwater sewer system, well inspection, initial sample collection (monitoring well, basement sump, and surface water), Community Air Monitoring Plan (CAMP) implementation, monitoring well installation, borehole geophysics, Flexible Liner Underground Technologies (FLUTe) hydrogeological characterization and multilevel well installations, monitoring well development, synoptic water elevation measurement and groundwater sampling, indoor air sampling, land surveying, and investigation derived waste (IDW) management. TRC's approved scope of work as found in the February 2023 Work Assignment (WA) package is included below:

Task 2 – Phase I Remedial Investigation

Mobilization, Utility Location Survey, Video Inspection of Stormwater Sewer Lines, and Well Inspection

Prior to intrusive activities, a private utility locating survey will be conducted, in addition to the public utility mark outs, to clear proposed monitoring well locations (shown on **Figure 1**). Vegetation clearing may be required prior to the utility locating survey and will be coordinated by TRC with the appropriate property owners. The utility locating surveyor will survey the area using, at a minimum, both GPR and EM/RF Pipe, Cable and Box locaters within an approximate 10-foot radius around each proposed investigation location. Subsurface utilities/structures/anomalies will be identified on the ground surface with spray paint and/or pin flags. TRC will discuss any required monitoring well repositioning, due to identified subsurface utilities/structures/anomalies, with the NYSDEC Project Manager prior to installation. It is anticipated that minor offsets (10 feet or less) will not require prior notification/approval.

In addition, a utility locating survey will be performed to trace the discharge piping from the building basement sumps to the final discharge location of each using, at a minimum, both GPR and EM/RF Pipe, Cable and Box locaters. Also, a video inspection of the stormwater sewer lines (labeled 1, 2, and 3 on **Figure 1**) will be performed to identify cracks, breaches, junctions/connections, other significant features, and damage to the sewers that may result in migration of contamination from sewers to subsurface soils and groundwater.

The existing Site monitoring wells and piezometers (up to 49 based on project documents, and as shown on **Figure 1**. Note: it is unclear if the piezometers still exist) will be inspected to assess condition. The existing wells and piezometers (hereinafter referred to as "existing wells") will be gauged using a water level meter for depth to water, total depth of the well, and depth to non-aqueous phase liquid (NAPL). The results will be compared to the available well construction information. If an existing well is found to require redevelopment (i.e., silt accumulation - the measured bottom of the well is shallower than the documented construction depth), it will be redeveloped as part of the development of newly-installed wells noted below. TRC will utilize a groundwater monitoring well inspection checklist to document the condition of the existing wells and will evaluate if repairs are needed. Any repairs that may require the services of a driller will be communicated to the NYSDEC Project Manager, and following approval, will be performed during well development noted below.

Initial Sampling

- Sump Sampling: Water samples will be collected from the three basement sumps within the existing building (shown on **Figure 1**) and analyzed for TCL VOCs +10 TIC – low level.
- Surface Water Sampling: One surface water sample will be collected from the outfall downstream of the catch basin in the parking lot (shown on **Figure 1**) and analyzed for TCL VOCs +10 TIC – low level.
- A brief memorandum presenting the results of the initial sampling and well inspections will be prepared prior to initiating well installation activities.

Monitoring Well Installation

A total of 12 monitoring wells will be installed during the field activities. Proposed monitoring well locations are shown on **Figure 1**. The proposed locations will be re-evaluated after the initial sampling has been completed. The proposed well locations are located on the Site or on NYS Department of Transportation (DOT) property (i.e., the wetland area). NYSDOT will be notified but it is not anticipated that permits will be required. Final monitoring well construction details will be determined in the field based on field conditions and the results of the borehole geophysics and FLUTe hydrogeological characterizations. The boreholes for the groundwater monitoring wells will be advanced to a depth of 5 feet below ground surface (bgs) via hand clearing or soft dig methods and then advanced to terminal depth using sonic drilling methods for the overburden wells, and a combination of sonic and air rotary drilling methods for the bedrock wells. Continuous soil cores at 10-foot lengths will be collected during sonic drilling to record observed soil geology/lithology. Drilling activities will be performed by a licensed drilling subcontractor and observed by TRC. During drilling, soil cores, cuttings, and drill rates, will be documented by TRC in a field logbook to develop a boring log that provides depths of permanent steel casings, depth to bedrock, overburden and bedrock lithology, potential fracture (soft rock) zones, and water loss (as applicable).

Monitoring Well	Overburden or Bedrock	Estimated Total Depth (feet bgs)	Estimated Depth to Bedrock (feet bgs)	Screen Interval (feet bgs)	Rationale
MW-100-R	Bedrock	55	15	50-55	Vertical delineation at MW-21R
MW-101-R*	Bedrock – Multilevel wells	55	15	TBD	Vertical delineation at MW-22R
MW-102-R	Bedrock	85	50	80-85	Vertical delineation at MW-10R
MW-103-R	Bedrock	85	50	80-85	Horizontal delineation
MW-104-R	Bedrock	85	45	80-85	Horizontal delineation
MW-105-R*	Bedrock - Multilevel wells	90	50	TBD	Horizontal delineation
MW-106-R	Bedrock	70	35	65-70	Horizontal delineation
MW-107-R*	Bedrock - Multilevel wells	100	60	TBD	Vertical delineation
MW-200-D	Overburden	60	60	50-60	Characterize plume centerline
MW-201-D	Overburden	55	55	45-55	Horizontal delineation
MW-202-D	Overburden	60	60	50-60	Horizontal delineation
MW-203-D	Overburden	60	60	50-60	Characterize plume centerline

Bedrock Monitoring Wells

Bedrock monitoring well installation will be completed in two mobilizations. During the first mobilization, boreholes will be completed using a combination of sonic and air rotary drilling methods. Eight-inch diameter (for 4-inch diameter bedrock boreholes) or 10-inch diameter (for 6- inch diameter bedrock boreholes) pilot holes will be advanced through the overburden from ground surface to the top of bedrock (estimated to be between approximately 15 and 60 feet bgs) using 6X8 or 8X10 sonic sampling systems. Soil samples will be collected continuously using the sonic sampling systems to confirm geology/lithology. Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.) and characterized using the Unified Soil Classification System (USCS). Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining, soil samples will be collected for laboratory analysis and analyzed for TCL VOC+10 TICs by the NYSDEC call-out laboratory.

After reaching the top of bedrock, air rotary drilling methods will be used to extend the boreholes approximately 5 feet into competent bedrock. Approximate 6-inch or 8-inch diameter steel casings will be installed to stabilize the overburden and allow completion of the bedrock boreholes. The steel casings will be grouted into place prior to further advancement of the bedrock boreholes to limit potential for leakage around the casings. Following the curing period (24 hours), borings of approximately 4-inch or 6-inch diameter will be advanced below the casings using air-rotary drilling methods to completion depth for all bedrock wells.

Limited well development (i.e., sufficient to remove foreign material introduced by drilling and drill cuttings) will be completed on the new boreholes in general accordance with WA Subtask 2.7. Boreholes for bedrock monitoring wells MW-100-R, MW-102-R, MW-103-R, MW-104-R, and MW-106-R will be completed at ground surface with expansion plugs and 12-inch diameter flush-to-grade protective steel enclosures. Boreholes for bedrock monitoring wells MW-101-R, MW-105-R, and MW-107-R will be completed with expansion plugs and 2-foot by 2-foot square steel vaults set in concrete pads extending approximately one foot laterally from the vaults in all directions (4- foot by 4-foot area of concrete and vault).

Borehole geophysics and hydrogeological characterizations will be completed on the newly installed boreholes as described for WA Subtasks 2.4 and 2.5 before the second mobilization. During the second mobilization, single screen monitoring wells will be installed at MW-100-R, MW-102-R, MW-103-R, MW-104-R, and MW-106-R with the finished protective surface casings and concrete pads in place. Wells will be constructed using 2-inch diameter Schedule 40 polyvinyl chloride (PVC) riser and screen. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface. The wells will be redeveloped to meet the water quality criteria as described for WA Subtask 2.7.

Deep Overburden Monitoring Wells

Deep overburden monitoring wells will be installed using sonic drilling methods. A 6X8 sonic sampling system will be advanced to the top of the bedrock (estimated to be between approximately 55 and 60 feet bgs). Soil samples will be collected continuously from ground surface to the top of bedrock using the sonic sampling system to confirm geology/lithology. Soil samples will be screened using a PID, inspected for indications of contamination (e.g., staining, odors, etc.) and characterized using the USCS. Geologic descriptions of the soil and field screening results will be recorded. In the event elevated PID readings are encountered and/or there is visible staining, soil samples will be collected for laboratory analysis and analyzed for TCL VOC +10 TICs by the NYSDEC call-out laboratory.

Wells will be constructed using 2-inch diameter PVC riser and screen inserted through the 8-inch sonic sampling system override casing. The annulus between the well and borehole wall will be backfilled with No. 2 sand to 2 feet above the well screen. A 1-foot thick (minimum) layer of choker sand (No. 00) will be placed directly above the filter pack. A 2-foot thick (minimum) hydrated bentonite seal will be placed directly above the choker sand, and the remaining annular space above the seal will be grouted to the ground surface.

The new overburden monitoring wells will be developed as described for WA Subtask 2.7. Monitoring wells MW-200-D, MW-201-D, and MW-202-D will be completed with flush mount manholes within concrete pads with locking expansion plugs. Monitoring well MW-203-D will be completed as an above ground steel standpipe set in a concrete pad. Final well construction may be modified based on encountered field conditions.

Borehole Geophysics

Borehole geophysical surveys will be completed at each newly installed bedrock well (MW-100- R, MW-102-R, MW-103-R, MW-104-R, MW-106-R, MW-101-R, MW-105-R, MW-107-R). The downhole geophysical surveys will be performed by a qualified subcontractor and observed by TRC. Prior to start of the surveys, the selected subcontractor will be required to submit for approval a proposed protocol for performing the geophysical surveys. The methods used to perform the surveys will include caliper, fluid temperature and conductivity (or resistivity), optical and acoustic televiewer, and/or heat-pulse flow meter under ambient and stress/pumping conditions. After completing the surveys, the subcontractor will furnish a report and provide a table summarizing the depths of potential water-bearing fractures at each borehole.

FLUTe Hydrogeologic Characterization

Following completion of the borehole geophysics, hydrogeological characterizations of the bedrock boreholes will be performed using FLUTe liners and profiling methods. TRC will subcontract with FLUTe to perform the hydrogeological characterizations of the bedrock boreholes as summarized below. Prior to start of the characterizations, FLUTe will be required to submit for approval a proposed protocol for performing the characterizations. The table below summarizes the proposed FLUTe characterization scope for each bedrock well.

Monitoring Well	Type of Bedrock Well	Blank Liner	NAPL Liner	FACT Liner & FACT Analysis	Transmissivity and Reverse Head Profiles	FLUTe Multilevel Wells
MW-100-R	4” diameter single screen	√	√	-	√	-
MW-102-R	4” diameter single screen	√	√	-	√	-
MW-103-R	4” diameter single screen	√	√	-	√	-
MW-104-R	4” diameter single screen	√	√	-	√	-
MW-106-R	4” diameter single screen	√	√		√	-
MW-101-R	6” diameter well for multilevel wells	√	√	√	√	√

Monitoring Well	Type of Bedrock Well	Blank Liner	NAPL Liner	FACT Liner & FACT Analysis	Transmissivity and Reverse Head Profiles	FLUTe Multilevel Wells
MW-105-R	6" diameter well for multilevel wells	√	√	√	√	√
MW-107-R	6" diameter well for multilevel wells	√	√	√	√	√

The FLUTe hydrogeological characterizations will be performed as follows:

- After completing the bedrock boreholes, blank liners will be installed in each open borehole to prevent contamination migration across the borehole and to facilitate the collection of hydrogeological characterization data using FLUTe profiling methods.
- NAPL liners will be installed along with the blank liners at each borehole to determine if there are zones of NAPL in the bedrock fractures. A NAPL liner is a hydrophobic material that is installed into the borehole and wicks NAPL contacted in the formation into the liner. Upon removal, NAPL can be directly observed in the form of stains or dye displacement on the liner material.
- In addition, FACT liners will be added to the blank and NAPL liners installed at MW-101R, MW-105-R, and MW-107R for mapping the dissolved phase contaminant distribution at 1- foot intervals. After two weeks, the NAPL and FACT liners will be retrieved from the boreholes and processed. Stains on the NAPL liners will be documented for their size and location by measuring the stain length and depth with a tape measure. The FACT liners will be cut in equal sections (1-foot lengths) and placed in sample jars for laboratory analysis. Each 1-foot length of FACT liner will be analyzed for TCL VOCs +10 TICs by a NYSDEC call-out laboratory. The analytical results will not be validated.
- Transmissivity and reverse head profiling will be performed at all bedrock borehole locations during liner installation and removal. Transmissivity profiling will be performed at each borehole by measuring the descent rate of the everting liner. The flow paths will be measured at a 6-inch resolution providing information on both flow paths and flow rates. Reverse head profiling will be performed by removing (inversion) the blank liner in a stepwise fashion to measure the new equilibrated head value beneath the liner.
- Blank liners will be reinstalled in MW-101R, MW-105-R, and MW-107R until multilevel wells are installed as described for WA Subtask 2.6.

<u>Construction of Multilevel Wells (Water FLUTe)</u>

Following completion of the borehole geophysics and FLUTe hydrogeologic characterizations at bedrock boreholes for MW-101-R, MW-105-R, and MW-107-R and processing and review of the resulting data, multilevel wells will be installed at these locations using Water FLUTe systems. A brief memorandum documenting the results of the borehole geophysics and hydrogeologic characterizations and providing recommendations for the multilevel well installations will be prepared prior to initiating the well construction activities. At each location, up to three separate bedrock zones will be selected for monitoring in consultation with NYSDEC. It is expected that the monitoring zones will range from approximately 5 to 20 feet depending on the density, spacing, and transmissive characteristics of fractures identified during the borehole geophysics and FLUTe hydrogeologic characterizations. The Water FLUTe systems will be pre-configured with separate screens, sample tubing, check valves, and sample ports for each monitoring zone. The Water FLUTe systems will be installed in the bedrock boreholes via eversion, similar to the blank liner installation process. Filter sand, bentonite, and grout will not be used as systems will seal the entire borehole, except for the screen zones to be monitored. Following installation, the components of each system will be tested to confirm the systems are performing according to manufacturer's design specifications.

Monitoring Well Development

Following installation of monitoring wells, utilizing surging and pumping techniques, the drilling subcontractor will develop each of the newly installed monitoring wells and any existing wells identified to need redevelopment during the initial sampling subtask (WA Subtask 2.2). The work assignment cost estimate provides for development of up to ten existing wells. Groundwater quality parameters (e.g., temperature, conductivity, turbidity, oxidation-reduction potential, etc.) will be monitored prior to, during (at an approximate frequency of once per well volume purged), and at the conclusion of development. Development will be considered complete when either turbidity is below 50 nephelometric turbidity units (NTUs), the well purges dry, or 3 well volumes have been removed, whichever occurs first. Purge water will be containerized for off-Site disposal.

Groundwater Synoptic Water Level Measurement and Sampling of Newly Installed Wells

A minimum of two weeks after well development activities have been completed, water level measurements in all of the existing and newly installed monitoring wells will be conducted in accordance with the FAP using an oil-water interface probe. As part of this WA subtask, the monitoring wells will be screened with a PID and gauged for total well depth, depth to water, and depth to NAPL.

One groundwater sample will be collected from each of the newly installed wells (total of 18 samples) following the synoptic water level measurements. Samples will be collected using low-flow sampling techniques. Field data will be recorded in a field logbook. Groundwater samples will be analyzed for TCL VOCs +10 TICs – low level. The sample collected from MW-105R (estimated bedrock plume fringe) will additionally be analyzed for natural attenuation parameters including alkalinity, chloride, dissolved gases (carbon dioxide, ethene, ethane, and methane), dissolved iron, dissolved manganese, sulfate, total dissolved solids, and total organic carbon. TCL VOCs +10 TICs – low level and natural attenuation parameter analyses (except for alkalinity and dissolved gases) will be completed by a NYSDEC call-out laboratory. Natural attenuation parameter analyses for alkalinity and dissolved gases will be completed by a TRC subcontracted laboratory. Purge water will be containerized for off-Site disposal.

Select existing wells in the overburden and bedrock will also be sampled for natural attenuation parameters to provide a snapshot of geochemical conditions to be assessed in Task 4 as part of the feasibility study.

- Existing Monitoring Well Sampling: Groundwater samples from up to 49 existing wells (shown on **Figure 1**) will be collected using low-flow sampling techniques. Existing wells found to require redevelopment as part of the well inspections performed during initial sampling will be sampled later with the newly installed wells (see Subtask 2.8 included in the WA).
- Prior to sampling, the monitoring wells will be screened with a photoionization detector (PID) and gauged for total well depth, depth to water, and depth to NAPL. Field data will be recorded in a field logbook. Groundwater samples will be analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) +10 Tentatively Identified Compounds (TICs) – low-level. Additionally, samples collected from select wells (MW-21R, MW-22R, MW-10R [bedrock plume core], MW-08R [bedrock plume fringe], MW-20R [downgradient bedrock], MW-10D, MW-10S, MW-24S, MW-24D [overburden plume core], and MW-02, MW-8S, MW-8D, MW-29D, and MW-29S [overburden plume fringe]) will be analyzed for natural attenuation parameters including alkalinity, chloride, dissolved gases (carbon dioxide, ethene, ethane, and methane), dissolved iron, dissolved manganese, sulfate, nitrate, total dissolved solids, and total organic carbon. TCL VOCs +10 TICs and natural attenuation parameter analyses (except for alkalinity and dissolved gases) will be completed by a NYSDEC call-out laboratory. Analyses for alkalinity and dissolved gases will be completed by a TRC subcontracted laboratory. Purge water will be containerized for disposal off-Site.

<u>Indoor Air Sampling</u>

One round of indoor air (IA) sampling will be conducted in the basement of the on-Site main building at Farrand Controls (refer to **Figure 1** for proposed locations). IA sampling will consist of completing the Indoor Air Quality Questionnaire and Building Inventory form and the collection of three IA samples, and one outdoor/ambient air sample. Collection of 8-hour IA samples is planned. It is anticipated that access to the building will be coordinated by the NYSDEC and/or the NYSDOH with assistance from TRC. Samples will be analyzed by a NYSDEC call-out laboratory for VOCs (64 compound list) by USEPA Method TO-15 with Selective Ion Monitoring (SIM). TO-15 with SIM analysis will be performed on the samples to achieve low level detection limits, in accordance with NYSDOH guidance. USEPA Method TO-15 SIM will provide detection limits of 1.0 micrograms per cubic meter for most analytes. The minimum reporting limit for trichloroethene, cis-1,2-dichloroethene, 1,1-dichcloroethene, carbon tetrachloride, and vinyl chloride will be 0.2 micrograms per cubic meter.

Land Survey

The land survey will include the locations and elevations (ground surface, top of well casing, top of PVC well riser, and top of protective cover, as applicable) of existing and newly installed monitoring wells. The measuring point on the PVC well riser will be permanently marked by the land surveyor. In addition, the location of stakes, flags, catch basins, and manholes associated with mark outs for the stormwater sewer lines will be surveyed. A survey report, documenting the coordinates/elevations of the newly installed monitoring wells and stormwater sewer line mark outs will be signed and sealed by a Professional Land Surveyor (PLS) licensed to practice in the State of New York, and provided in the Phase I RI Report.

Investigation Derived Waste

IDW is anticipated to include the following: decontamination fluids, well development and purge water, soil and rock drill cuttings, used personal protective equipment (PPE), and disposable sampling equipment. Wash and rinse water used for equipment decontamination, development water, and purge water will be containerized in a closed top frac tank (10,000-gallon capacity). Drill cuttings and other solids will be containerized in a 20 cubic yard roll-off container. Waste characterization sampling and analysis will be performed prior to off-Site disposal. Waste characterization sample analysis will be performed by a NYSDEC call-out laboratory. Used PPE and disposable sampling equipment will be containerized in DOT-approved 55-gallon drums for off-Site disposal. Materials containerized for off-Site disposal will be temporarily staged at locations on-Site that are acceptable to the NYSDEC and the property owner (e.g., parking lot of the Farrand Controls facility). Containerized materials will be clearly marked to indicate the contents of the containers, the date of generation, and the material source. IDW will be properly disposed of off-Site.

5. Hazard Assessment

This Health and Safety Plan (HASP) assumes that an ongoing hazard assessment process with the HSO (or his/her designee), Project Manager, OSC and field staff (including the On-Site HSO) will take place regularly (via meetings/teleconferences), supplemented by as needed communication on project safety needs, to ensure the project work is conducted at a high level of technical excellence both safely and efficiently. Where the on-going hazard assessment indicates the presence of hazards, tasks, or other activities that are not adequately covered by the HASP and supporting documentation and/or staff training levels, supplemental planning will be conducted and documented in a revised or higher-level HASP document and appropriately trained personnel assigned.

5.1 Chemical Hazards

The following contaminants are known and/or suspected to be present at the site:

- VOCs, including:
    - 1,1,1-trichloroethane
    - Dichloroethane
    - Dichloroethene
    - Freon-113
    - Trichloroethene
    - Vinyl chloride
- Light non-aqueous phase liquid (LNAPL)
- Dense non-aqueous phase liquid (DNAPL)

TRC also anticipates the presence of the following chemicals in laboratory bottles used as sample preservatives: Hydrochloric Acid (HCl) (VOC VOA vials) and methanol (VOC high-low VOA vials). Safety Data Sheets (SDS) for preservatives and decontamination products are provided in **Appendix A**. Sample bottles containing hazardous preservatives will be handled with care. Sample bottles will be checked for leaks and lids tightened. Cut resistant and chemical resistant gloves and safety glasses will be worn at all times when handling sample bottles (see Section 5.2 for information concerning edges and material handling).

Isobutylene may be used for brief periods each work day to calibrate a PID. One hundred parts per million (ppm) isobutylene will be primarily contained in a Tedlar® bag. Any gas that is released to the air will quickly disperse and will not pose a threat to on-site workers. No further monitoring is required for isobutylene

5.2 Physical Hazards

Physical hazards that may be encountered at the site are outlined below. If hazards are identified by the ongoing hazard assessment process, which are not address by this HASP, work shall be stopped and the HSO (or his/her designee), Project Manager, OSC or On-Site OSC, as appropriate, shall be contacted to determine if additional safety procedures and programs should be employed at the site.

Dust – When conducting any ground disturbing activities, be cognizant that the dust has potential to contain hazardous chemicals and should not be inhaled. Whenever possible dust reduction by wetting shall be used. If dust is billowing, wetting the area, letting the dust settle, working from an upwind direction, and/or respirator with P100 cartridges (with proper fit test, training and medical monitoring) is recommended to reduce exposure.

Edges/Material Handling – Cut resistant gloves are required to be worn at all times while performing tasks that have the potential for hand injuries. A glove selection guideline is presented in **Appendix B**.

Excavations – Stay clear of excavation walls. TRC personnel will not enter an excavation, in accordance with 1926 Sub Part P. The call-out contractor must provide a competent person on site, if one is required by the planned activities. Side cuts should conform to 1926 Subpart P requirements, or shoring should be used. All open excavations should be secured using traffic cones, barrier tape, or barricade signs stating "Do Not Enter Excavations", especially if left open overnight. See **Appendix C** for an Excavation Hazard Recognition Guide for Trenching and Shoring and Site Assessment Questions to facilitate your understanding of potential hazards and other guidance.

Ground Fault Circuit Interrupters (GFCI) and Electrical Cords – GFCIs will be used on all 120 volt, single phase, 15 and 20-ampere receptacle outlets when electrical equipment is used on-site. Electrical cords will be inspected for cracks, tears, or general wear to the outer protective casing. If the wiring of the cord is exposed, the cord will be repaired, if possible, or discarded. All extension cords will contain a grounding prong. If the grounding prong is missing, or if the cord was designed to contain only two prongs, the cord will not be allowed for use. These cords are dangerous and cannot be grounded through the use of a GFCI.

Hand Tools – Use only the appropriate tool for the task at hand. Use the tool(s) as designed, described, and intended by the manufacturer. Hand tools will meet the manufacturer's safety standards. Hand tools will not be altered in any way. Makeshift tools will not be used. At a minimum, hand and eye protection will be used when working with hand tools (see glove selection guide provided herein). Wrenches, including adjustable, pipe, end and socket wrenches, will not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges and chisels, will be kept free of mushroom heads. Wooden handles will be free of splinters or cracks and secured tightly to the tool. At all times use appropriate hand protection when utilizing hand tools.

Heavy Equipment/Drill Rigs – Use caution around drill rigs, construction equipment, and open excavations. Ensure the equipment operator is aware of the location of on-site personnel at all times to avoid potential injuries (e.g., maintain eye contact with the equipment operator). A spotter should be used to direct the movement of heavy equipment. A swing zone should be established with cones behind any excavators to prevent injury during movement of equipment. Exercise caution and wear protective equipment as noted herein around the equipment to guard against crushing and pinching hazards. On-site personnel will maintain a distance (approximately 10 feet) from mechanical hazards associated with heavy equipment. All field team members working near or with equipment with emergency shut-off switches should be aware of the locations and situations when these switches should be used.

Hostile Individual(s) – Most personnel who are encountered during work will not be hostile, however if a hostile individual is encountered you should not confront them. You should back away and go to your vehicle or other safe location where you can isolate yourself from the hostile person(s). Once safe, if you are continuing to be harassed you should contact the local police for assistance. Contact the Project Manager or OSC once the situation is safe and under control.

Lighting – There are areas/time within the work area(s) at the site which will potentially have little to no lighting. Lighting shall be utilized to make the work area and nearby hazards are illuminated. If gasoline powered equipment must be used to power portable lights, the generator shall be placed outside in a well ventilated area.

Manual Lifting – Improper lifting can lead to a variety of injuries including back strains, muscle pulls and joint damage. It is important for all personnel to understand proper lifting techniques and to utilize safe lifting procedures when handling materials. Generally, no one person should lift more than 50 pounds without assistance. Mechanical means should be used whenever possible.

Noise – Hearing protection must be worn when noise levels exceed 85 dBA in the work area. If you need to raise your voice to be heard at the work site, then hearing protection should be worn. Hearing protection will be worn near drill rigs.

Power Tools – All power tools will be inspected regularly (at least on a daily basis) and used in accordance with the manufacturer's instructions and its capabilities. Electrical tools will not be used in flammable areas, unless they are approved for that purpose. Portable electric tools will be used only with a GFCI. Proper hand, eye and hearing protection will be used when working with power tools and all appropriate safety guards must be in place. Personnel will be trained in the proper use of the specific tool. Any defective power tools will be immediately tagged and removed from service. Tools will be stored properly after use.

Pressurized Fluids/Gases – All compressed gases are hazardous due to the high pressures inside the cylinders. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder. Damaged cylinders can become projectiles resulting in severe injury and property damage. An unsecured or uncapped cylinder can become a cause of a major accident. Cylinders shall be secured when not in use, in transport, and as much as possible when in use.

Slips, Trips and Falls – Be aware of uneven ground and buried debris (e.g., metal, plastic, etc.) to avoid potential slip/trip/fall hazards, and use caution near open excavations. Maintain good housekeeping practices to minimize physical hazards.

Traffic Hazards – Driving to and from the site each day is considered a physical hazard. Directions and travel time to the site should be determined in advance (a.k.a. Journey Management Planning) and adequate time should be allocated to drive safely. The use of cellular phones is prohibited, and distracted driving should be avoided. Seatbelts shall be worn at all times while the vehicle is moving. Use caution around traffic flow. Ensure proper traffic control (e.g., signs, traffic cones, barriers, etc.) are in place prior to and throughout the work day where work takes place in or near traffic. Work personnel must wear ANSI-rated class 3 reflective traffic vests at all times. A site-specific traffic management plan describing procedures to be employed, including barriers, signage, etc., will be used for each drilling location.

Utilities – Dig Safely New York and non-member utilities must be notified at least 72 hours prior to commencing any intrusive activities. Use extreme caution when operating heavy equipment near utilities. Excavation and drilling locations will be selected that are located at safe distances from utility hazards. Prior to the operation of any heavy equipment, the site shall be inspected for potential overhead hazards (e.g., wires, tree branches, etc.). A minimum clearance of 10 feet must be maintained between equipment and overhead utility lines. If contact is possible (i.e., equipment, drill rig, excavator, etc.) one or more of the following will be done: 1) Power sources will be disconnected by the utility; 2) Power sources will be shielded by the utility; 3) Object will get no closer than 10 feet to prevent arcing, unless site specific conditions or weather conditions warrant greater separation per best professional judgment, or as directed by utility representatives; and, 3) Evaluate the need for shielding and coordinate with local utility representatives.

Weather – Heat and cold stress are a potential concern for on-site workers. Take breaks as needed to cool down, replenish fluids and/or warm up. Please refer to **Appendix D** for the signs, symptoms and precautions for cold and heat stress. Work may occur during a time of year when thunderstorms are possible/likely. If thunder or lightning is noted by onsite personnel, work will cease until the storm passes (thunder and/or lightning ceases and is not observed over at least a 30-minute period). Personnel will seek shelter in buildings or vehicles.

Working Over/Near Water – All workers working over/near water will be required to wear a Type I, II, or III Personal Floatation Device (PFD). When continuous fall protection is used (without exception) to prevent employees from falling into the water, the drowning hazard has effectively been removed. Therefore, PFDs are not required when utilizing continuous fall protection.

5.3 Biological Hazards

Biological Waste – This includes feces, urine, needles/sharps and other materials which may contain biological matter from humans or animals. This material should be avoided and not handled in any way. If biological waste impedes the planned scope of work the Project Manager or OSC should be contacted to discuss appropriate actions.

Blood-Borne Pathogens – Injuries received in the field may require assistance from a field team member with appropriate first aid/first responder training to perform first aid. Contact with blood and certain body fluids can contain pathogens that may be transmitted by contact with an open wound by the caregiver. The following precautions should be used when giving first aid:

- Use nitrile gloves to avoid contact with blood/fluids. Spent bandages and gloves used to perform first aid should be placed in a plastic bag and properly disposed.
- Blood/fluid should be cleaned from surfaces that may be contacted by other individuals.

- Use an appropriate barrier if required to perform rescue breathing.

Ticks - Ticks generally favor areas of high grass and dense vegetation so to the extent possible, these areas should be avoided. It is advisable when entering these areas to tuck pants into socks and to wear a light colored long sleeve shirt to help spot ticks before they bite. DEET-based insect repellents may be worn to repel ticks but hands should be washed thoroughly after use and DEET should not be sprayed directly onto the skin surface. Self-checks should be made frequently and at least at the end of the field day for ticks when working in or near vegetated areas.

If discovered, the tick should be removed with a pair of tweezers and saved in a sealed plastic bag. Sometimes, tick bites occur but the tick may not stay attached, followed by a rash developing in the area within a few days of the bite**. If bitten by a tick or a bulls-eye like rash develops, it is advisable to consult WorkCare**.

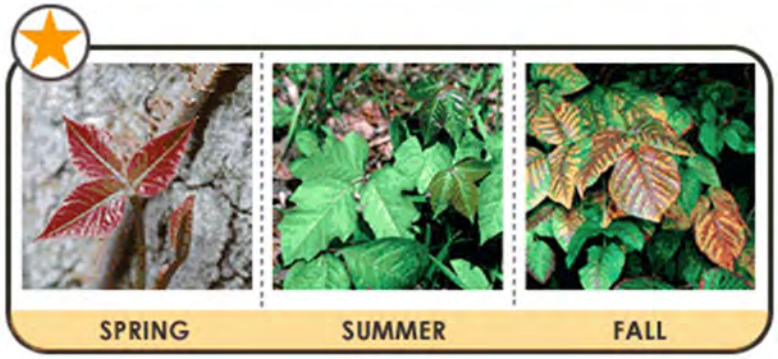
Spiders – Spiders typically seek cover in dark protected areas. Common areas where spiders may be encountered are heavy vegetation and trees. Spiders also are found in basements and enclosed spaces such as sheds, protective well covers, etc. Spider bites may cause swelling, pain and respiratory problems. Avoid dense vegetation, and use caution when sampling in dark poorly illuminated locations. If bitten, wash the area and use ice on the bite area to reduce swelling. If respiratory stress, significant pain or swelling is noted, or discoloration around the bite area occurs, seek immediate medical attention.

Stinging Insects – Like spiders, wasps and yellow jackets often nest in dense vegetation and in the ground, or in protective casings on monitoring wells and shielded gate locks. A sting from these insects can cause pain, swelling, and respiratory problems that may be life-threatening to certain individuals. If stung, remove stinger (if present) using tweezers, or similar, and wash the area and use ice on the sting area to reduce swelling. If respiratory stress, significant pain or swelling is noted, or discoloration around the sting area occurs, seek immediate medical attention.

Dogs and Wild Animals – Dogs often are not leashed and may be unfriendly. Bites from dogs and wild animals can cause infections or transmit disease. In general, it is best to not approach dogs even if they appear to be friendly, and wild animals should never be approached. If bitten, the area should be washed with soap and water. If the bite resulted in puncturing or tearing of the skin, the wound should be covered with a sterile dressing and medical attention should be sought immediately. A description of the dog should be noted and if possible, the dog's owner.

Plants – There are many types of plants which can cause irritation or allergic type reactions. Examples of some encountered on TRC sites include the following:

***Poison Ivy* –** the trademarks of this plant are its solid green, pointed leaves that hang from the stem in groups of three. It grows as both a vine and a shrub. The look of poison ivy can change with the seasons. It produces yellow-green flowers in the spring and its green leaves can change to yellow and red in autumn.



***Wild Parsnip/Giant Hogweed* –** Both plants are part of the carrot family and can grow up to 15 feet tall. They look similar to giant Queen Anne's lace with bristly stalks. Contact with the sap from the plant can cause phytophotodermatits or irritation (sometimes severe) when skin is exposed to sunlight.

<u>Pandemic Preparedness</u> – A "pandemic" refers to an epidemic that has spread over several countries or continents, usually impacting a large number of people. A pandemic has the potential to significantly impact routine services. A pandemic disease presents a serious health risk and could prevent TRC from performing project-related tasks. The risk to employee health and the business will vary based on the geographic area of the pandemic and the potential severity of the disease. Pandemic risk assessments will be performed by the TRC Corporate Safety team who will provide direction to field personnel.

TRC will follow health and travel precautions issued by the respective authorities. Employees should stay at home when sick or otherwise experience symptoms that are consistent with the pandemic disease. When at a project site, infection control measures should be enacted, which are essential components of pandemic management and a component of public health measures. These essential measures include:

- Practice frequent hand washing. According to the CDC, washing hands with soap and water is the best way to get rid of germs in most situations. If soap and water are not readily available, you can use an alcohol-based hand sanitizer that contains at least 60 percent alcohol. You can tell if the sanitizer contains at least 60 percent alcohol by looking at the product label.
- Obtain immunizations recommended by healthcare providers to help avoid disease.
- Practice social distancing to increase the space between employee work areas and decreasing the possibility of contact by limiting large or close contact gatherings and avoid shaking hands.

- Frequently disinfect all areas that are likely to have frequent hand contact (like doorknobs, faucets, handrails, etc.).

5.4 Radiological Hazards

No radiological hazards are expected at the site. If any new condition is encountered during this activity, the HASP will be adjusted accordingly.

Radiation (ionizing) – Exposure to ionizing radiation can be controlled by one of three methods. Time, distance, or shielding. Limit your time near the radioactive source. Keep your distance from the radioactive source. Shield yourself from the radioactive source with appropriate shielding material. If the radioactive source(s) are from TRC equipment, the TRC employee using the equipment needs required training to use the equipment, and must be monitored using a dosimeter badge. Update contact information for TRC subject matter expertise and regulatory authorities.

X-Ray Fluorescence Instruments (a.k.a., XRF Guns) – XRF units for field metals analysis are only to be used by trained employees with radiation safety training. Licensing requirements can vary by state. Coordinate with the TRC Corporate Safety team before utilizing in the field to set up dosimetry protocols and instrument specific safety procedures.

6. Personal Protection Monitoring

Personal Protection Monitoring Equipment and Use Recommendations: The following table outlines monitoring equipment needs and rationale. Note that an upgrade to a higher level of respiratory protection (C or higher) will warrant revision or addendum to this HASP and consultation with the TRC Corporate Safety team before work recommences.

Table 2: Monitoring Equipment Use Recommendations			
Instrument	**Use Code**	**Action Levels**	**Notes/Rationale**
PID	C	5 ppmv*	Recommended for VOC screening to monitor airborne VOC concentrations in breathing zone levels. If PID readings are sustained above 5 ppmv in the breathing zone for at least 5 minutes, move to an upwind location for 15 minutes. After 15 minutes, measure again. If PID readings are still above 5 ppmv in the breathing zone, contact the Project Manager or OSC to evaluate suitable response actions. Any upgrade in respiratory protection will be coordinated with the TRC Corporate Safety team. Withdraw from area if PID readings exceed 50 ppmv.

Table 2: Monitoring Equipment Use Recommendations

Instrument	Use Code	Action Levels	Notes/Rationale
TSI Dustrak™ (or equivalent)	C	> 150 µg/m3; 15 minute average**	Used where contaminants could adhere to fugitive dust, and where fugitive dust migration could potentially serve as a significant exposure pathway. Half-faced APR for particulates to be used intermittently/temporarily where dust control measures cannot maintain dust levels below action level. Use is optional for dust levels below the action level. Use of a half-face APR for dust does not require CIH approval where dust action level excursions are limited in duration, and where dust control measures will be implemented until below the action level. However, personnel must be medically qualified, fit tested for half-face APR use, and trained in the use of the APR.
O^2/LEL	C	19.5%	Recommended for landfill, lagoon, excavation, sewer, and anaerobic degradation site work. Required for confined space work.
H_2S Meter	C	1 ppm	Recommended for landfill, lagoon, excavation, sewer, and anaerobic degradation site work. Required for confined space work.
CO	C	25 ppm	½ of the PEL (PEL = 50 ppm)
CGI	C	10% LEL	Recommended safe level to prevent explosive conditions.
MINIRAM (or equivalent)	O		Supplement operation of Dustrak™ stations for work near sensitive receptors.
Radiation meters	N/A		Not known or anticipated to be a Contaminant of Concern.

Notes:
* Site/project specific action levels for VOCs may be established in consultation with the OSC.
** Above background upwind levels

PID – Photoionization detector
LEL – Lower Explosive Limit
O_2 – Oxygen
H_2S – Hydrogen Sulfide
CO – Carbon Monoxide
ppm – Parts per Million
CGI – Combustible Gas Indicator
VOC – Volatile organic compound
ppmv – Parts per Million Volume
APR – Air Purifying Respirator
CIH – Certified Industrial Hygienist
PEL – Permissible Exposure Limit
µg/m3 – micrograms per cubic meter

Use Codes: R – Required, C – Condition specific, O – Optional, N/A – Not applicable

Personal Protection Monitoring Procedures: When necessary, the OHSO will measure organic vapor concentrations in the breathing zone using a PID. Fugitive dust emissions are not anticipated to be a concern. When required, air monitoring for dust will be performed using a combination of real-time dust monitoring upwind and downwind of the work area, and at a point near the closest receptor.

Personal Protection Exposure Limits: The following table summarizes anticipated concentrations and accepted exposure limits of chemicals potentially present within the work site.

Table 3: Summary of Exposure Limits – Known or Suspected Site Impacts

Chemical of Concern	Detected Concentration	OSHA PEL/ACGIH TLV
Volatile Organic Compounds (VOCs)	Unknown	200 ppm (OSHA PEL for PCE) 200 ppm (OSHA PEL for TCE) 200 ppm (OSHA PEL for DCE)
Semi-volatile Organic Compounds (SVOCs)	Unknown	0.2 mg/m^3 (OSHA PEL for PAHs)
Polychlorinated Biphenyls (PCBs)	Unknown	1,000 µg/m^3 (OSHA PEL for PCBs containing 42% chlorine) 500 µg/m^3 (OSHA PEL for PCBs containing 54% chlorine)
Metals	Unknown	50 µg/m^3 (OSHA PEL for lead) 10 µg/m^3 (OSHA PEL for arsenic) 0.2 mg/m^3 (OSHA PEL for cadmium) 0.5 mg/m^3 (OSHA PEL for chromium) 0.2 mg/m^3 (OSHA PEL for selenium) 0.01 mg/m^3 (OSHA PEL for silver) 0.5 mg/m^3 (OSHA PEL for barium) 1.0 mg/10m^3 (OSHA PEL for mercury)

Notes: Exposure and hazard data obtained from the NIOSH Pocket Guide to Chemical Hazards unless otherwise noted.

ppm – parts per million
TLV – Threshold Limit Value
OSHA – Occupational Safety and Health Administration
PEL – Permissible Exposure Limit
PCE – Tetrachloroethene
TCE – Trichloroethelene
DCE – Dichloroethene
PAHs – Polycyclic aromatic hydrocarbons
µg/m3 – micrograms per cubic meter

Table 4: Preservatives and Decontamination Products

Chemical of Concern	On-Site Usage and Potential Exposures	Control Method
Hydrochloric Acid (HCl)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample containerization.	5 ppm (OSHA PEL)
Methyl Alcohol (methanol; MeOH)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample containerization.	200 ppm (OSHA PEL)

Table 4: Preservatives and Decontamination Products		
Chemical of Concern	**On-Site Usage and Potential Exposures**	**Control Method**
Nitric Acid (HNO_3)	Less than 20 ml quantities used for sample preservation. Air phase exposure is expected to be minimal and incidental to sample containerization.	5 mg/m3 (OSHA PEL)
Isobutylene	100 ppm gas for use during calibration of PID instruments.	No specific exposure limits for isobutylene (simple asphyxiant). Maintain oxygen levels above 19.5%. Before attaching regulator to cylinder, verify that the regulator is off. Before opening regulator, make sure that tubing connecting regulator to monitoring device/ Tedlar® bag is secure. To use a Tedlar® bag, put bag control valve in an open position and close after filling. Before disconnecting gas from the instrument and/or Tedlar® bag, verify the regulator is closed. Empty bag of contents after calibration in a downwind position and/or to avoid inadvertent inhalation.
Notes: ppm – parts per million ml – milliliters PID – Photoionization Detector OSHA – Occupational Safety and Health Administration PEL – Permissible Exposure Limit		

7. Personal Protective Equipment

TRC personnel will use Level D PPE as noted/modified below:

Table 5: Level D Personal Protective Equipment	
Item	**Rationale/Notes**
Hardhat	American National Standards Institute/International Safety Equipment Association (ANSI/ISEA) Z89.1-2009 rated hard hats will be worn by personnel at all times when overhead hazards are present, including electrical.
Hearing protection	Hearing protection will be worn by all personnel exposed to at least 85 dB of sound during the workday. A good rule of thumb to use in determining whether background noise is 85 dB or higher is if you must shout to be understood by somebody about one arm-length away, that background noise is hazardous.
Safety boots (steel or composite toe and shank)	Electrical Hazard (EH) rated safety-toe safety boots will be worn by all personnel during project work described in this HASP.
Eye protection (safety glasses)	ANSI rated eye protection (Z87 or Z87+) is required to be worn at all times when onsite or when personnel are exposed to flying debris, chemical vapors or particulates. Chemical splash goggles will be worn for protection against chemical gases, vapors or particulates. Safety glasses will be worn for protection against flying objects.
Safety vest	ANSI Class 2 safety vest is required at all times when onsite. Utilize in areas in or near vehicular traffic of any kind on or off property.
Chemical Protective Clothing (CPC) and Gloves	CPC and gloves will be inspected according to TRC's Personal Protective Equipment Program. CPC will be chosen with assistance from the OSC according to the chemical hazards present. Gloves are to be changed between samples to avoid cross-contamination.
Cut resistant work gloves	As indicated herein, use Cut and Abrasion Resistance Level 2 to Level 4 gloves when necessary for hand protection during field tasks. See **Appendix B** for a Glove Selection Guide. ***Leather work gloves are expressly prohibited.***
Electrical Safety	8 cal/cm^2 Flame Resistant (FR) clothing
Personal Floatation Device (PFD)	Type I, II, or III PFD is required to be worn at all times when working over/near water.

A basic first aid kit will be readily available on-site in the event of an emergency. Fire extinguishers should be present within 50 feet of wherever more than 5 gallons of flammable or combustible liquids or 5 pounds of flammable gas are being used at the site, including operational equipment. All personnel working on or around the equipment should know the location of and how to operate the fire extinguisher. Ensure the fire extinguisher is in working order by checking the manufacture and/or most recent inspection dates.

8. Personnel and Equipment Decontamination Plan

At minimum, personnel and equipment decontamination will include the following:

Equipment Decontamination: There is a possibility that site media contacted during work activities contain compounds described in **Table 3**. All equipment that comes in contact with media needs to be decontaminated before it is removed from the job site. To properly decontaminate equipment that comes in contact with media, the following procedure should be followed:

- Brush accumulated material off equipment that has come in contact with impacted media. The material shall be returned to the location from which it came or disposed of properly;
- Wipe parts of the equipment that came in contact with the media down with cloth, rags or heavy-duty paper towel damp with non-phosphate concentrated laboratory-grade soap (i.e. Alconox© or Liquinox©);
- Follow up with a wipe from a separate cloth, rags or heavy duty paper towel damp with potable water; and
- PPE and cloth, rags or heavy duty paper towels can be disposed of in the regular waste stream.
- If equipment becomes grossly impacted with site media, equipment shall be steam cleaned over a decontamination pad.

Personnel Decontamination: In general, contamination of personnel shall be prevented through the use of PPE. At minimum, nitrile gloves shall be worn during contact with impacted material or chemical in addition to other Level D PPE.

9. Required Personnel Training

TRC field personnel will have the training outlined below before on-site work activities:

Table 6: Project Training Requirements

(* required for all sites; but minimum recommended)
Check "A" if training required for everyone, and check "T" if training required for specific task or per notations.

A	T	Subject	Reference	
			29 CFR 1910	29 CFR 1926 or Other
☒	☐	HAZWOPER 40 hour*	1910.120	1926.65
☒	☐	3-Day HAZWOPER Supervised On-site*	1910.120	1926.65
☒	☐	8-Hour HAZWOPER Refresher*	1910.120	1926.65
☐	☒	8-Hour Supervisor HAZWOPER*	1910.120	1926.65
☐	☒	First Aid, CPR[*,1]	1910.151	1926.23,.50

Table 6: Project Training Requirements				
(* required for all sites; but minimum recommended) Check "A" if training required for everyone, and check "T" if training required for specific task or per notations.				
☒	☐	Hazard Communication (HAZCOM)	1910.1200	1926.59
☐	☒	DOT/IATA Shipping Training	1910.1201	49 CFR 172.704
☐	☐			
☐	☐			
☐	☐			
Client-specific training:_______________ ☐ Not Applicable ☐ Specify				
Client-specific training:_______________ ☐ Not Applicable ☐ Specify				
Client-specific training:_______________ ☐ Not Applicable ☐ Specify				
Note: 1 Per the TRC Health and Safety Policy and Procedure Manual, each TRC project will have at least one certified CPR/first aid trained person on site at all times. All Project Managers and anyone acting as the on-site Health and Safety Officer must be current in First Aid/CPR.				

Project training requirements beyond those provided in the above table will require a HASP revision/upgrade or concurrence of the TRC Safety Director or ECR Safety Manager.

10. Medical Monitoring

Medical monitoring will apply routinely to all employees who are or may be exposed to hazardous substances or health hazards at or above the established permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year (40 CFR 1910.120[f][2][i]). Said TRC field personnel will have the medical surveillance outlined in the table below prior to commencing on-site work activities.

Table 7: Medical Surveillance Required			
*Baseline is minimum recommended.			
	29 CFR 1910	**29 CFR 1926 or Other**	**Notes**
☒ HAZWOPER Physical - Baseline*	1910.120	1926.65	
☒ HAZWOPER Physical – Annual	1910.120	1926.65	
☐ HAZWOPER Physical - Biennial*	1910.120	1926.65	
Client-specific drug testing[1]	☒ Not Applicable ☐ Specify		
Client-specific medical monitoring[1]	☒ Not Applicable ☐ Specify		
Site-specific medical monitoring:	☒ Not Applicable ☐ Specify		
Note: [1] Client required drug testing or medical monitoring should be coordinated through the Project Manager.			

TRC has a Drug and Alcohol-Free Workplace Policy (TRC Academy Course #900013753). TRC may require employees or subcontractors to be tested upon reasonable suspicion, following accidents or incidents during work activities, or during travel to or from a project site. Client policies may be stricter in regard to procedures following an accident. Project Managers must be aware of these and inform employees and subcontractors of any additional requirements.

11. General Safety Requirements

The general safety rules listed below apply to all TRC personnel present at the site.

- A tailgate health and safety meeting will be held with all field team members each day prior to the start of work, the start of a new shift, upon changing of work conditions or job task duties, or when new field team members arrive onsite.
- Adhere to all requirements of this HASP.
- Wear protective clothing appropriate for the designated level of protection and decontaminate before entering clean areas when applicable.
- Use safety equipment in accordance with OSHA guidance and labeling instructions.
- Maintain safety equipment in good condition and proper working order and make sure that the equipment is calibrated prior to use.
- Immediately report unsafe acts or conditions to the Project Manager and OSC.
- Eating, drinking, and smoking are prohibited on site, except in designated areas.
- Maintaining a position upwind from intrusive activities is encouraged.
- The emergency shutoff switch should be demonstrated to be working prior to initiating drilling.
- An adequately stocked first-aid kit will be maintained at the work site.

12. Tailgate Safety Meetings

- A tailgate safety meeting will be conducted daily prior to commencement of the work day, the start of a new shift, upon changing of work conditions or job task duties, or when new field team members arrive onsite (see checklist provided in **Appendix E**).
- Topics covered by the tailgate safety meeting will include, but not be limited to, scope of work and who will conduct each task, potential hazards, weather forecast, PPE, emergency procedures and the route to the medical facility, site conditions and features, and, communication guidelines related to stakeholder engagement and visitors.
- Safety meetings must also be held to address modifications to this HASP and any addenda prepared to supplement the HASP.
- Subcontractors and personnel present at the tailgate safety meeting shall be required to sign an acknowledgement form after each meeting.

13. Emergency/Contingency Plan

Before commencing any on-site operations, the TRC OHSO will advise all personnel of potential emergencies. Personnel will be advised on their roles in the event of an emergency, and the steps to take for a timely and controlled response.

<u>Communication networks/chain of command</u> – All on-site personnel will communicate any accident, injury or near miss to the TRC OHSO who will provide instruction on how to proceed further.

<u>First Aid / Safety Equipment</u> – First aid equipment should be readily available in the event of an emergency. First aid equipment should include a well-stocked first aid kit, fire extinguisher and emergency eye wash.

<u>Evacuation Plans and Refuge Area</u> – All personnel should safely remove themselves from danger in the event of an emergency and safely access the refuge area. The refuge area should be in an upwind location a safe distance from the work zone. The refuge area will be determined during the daily safety briefing.

<u>Notifications of Fire, Police and Emergency Facilities</u> – In the event of an emergency that cannot be controlled by on-site personnel, the appropriate emergency contact shall be notified. All personnel shall remove themselves from the area of danger and wait for the arrival of help in the predetermined refuge area.

<u>Non-Emergency Medical Assistance</u> – If an injury does occur and it is not life threatening, then the employee or employee's supervisor/project manager should contact WorkCare as soon as possible, but within the first hour after an injury. WorkCare information is proved in **Appendix F**. This information will help assist the injured employee by connecting them with instant access to a medically qualified professional in order to provide guidance on appropriate first aid measures and medications.

14. Stop Work

TRC personnel are all empowered, responsible, authorized and obliged to stop work at any time we feel that our safety or the safety of others is, or could be, compromised. When a stop work occurs the Project Manager and/or OSC should be contacted to discuss the reason for the stop work and the corrective action(s) needed to resume work safely. Work on an activity shall not continue until the unsafe condition has been corrected.

15. Safe Catches

A "Safe Catch" is a potential hazard or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries. It is everyone's responsibility to report and/or correct these potential incidents immediately. Please complete the form provided in **Appendix G** as a means to report these "Safe Catch" situations and submit to your local OSC Representative and Mike Glenn, National Safety Director.

16. Observations

Note that the Project Manager and/or OSC may notify field staff that their site activities may be the subject of Safety Observation, an integral part of the continuous improvement safety culture promoted at TRC. If subject to an observation, please note the following:

- The Observation will tend to focus on the highest risk activity (as a general example, drilling in a public right-of-way).
- Follow-up observations may need to occur on previous observations, depending on prior data collected.
- The observer's preparation before visiting the site will be a review of the HASP, JSAs, client-specific requirements, etc., and a review of the work scope with the Project Manager to ensure the context of the work is well understood in advance.
- Review items may include PPE, body use and positioning, work environment, operating procedures, and tools and equipment.
- The observation should last between 30 and 60 minutes.

Both positive and negative observations are candidates for documentation and later discussion. The overarching goals are to identify and correct questionable practices and to identify and promote good, safe and efficient practices. It is a data gathering process that will allow TRC safety specialists to identify root causes for safety issues in both categories to better inform policy decisions.

17. Incident Reporting

In case of an incident, TRC personnel must report the incident immediately to their project manager/supervisor and/or OSC as well as the client's representative and follow the TRC Incident Response and Reporting Process (see **Appendix H -** In Case of Emergency and Incident Reporting). Required Incident Notification or Auto Incident Report forms must be completed within 24 hours following the incident. If neither is available, the incident shall be reported to the TRC Safety Director. Incident/injury/exposure information must be recorded per TRC policy and will be the basis of any incident investigations.

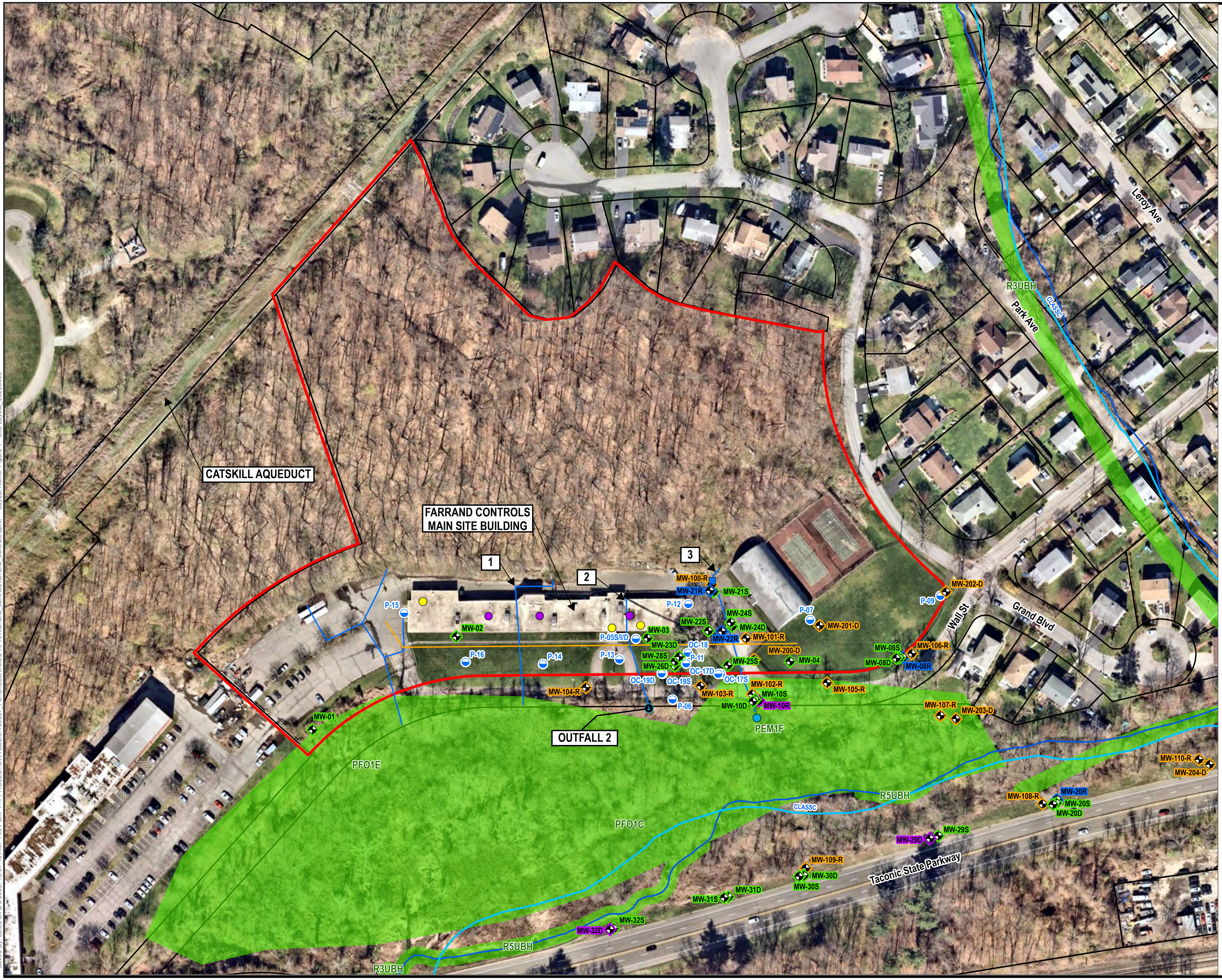
18. Job Safety Analysis

It is anticipated that the standard operating procedures (SOPs) detailed in the Generic Field Activities Plan (FAP) will be utilized for all work practices. If site specific activities require additional or alternate procedures, TRC will assess the task hazards and controls using separate job safety analysis forms (JSAs). Prior to use in the field, JSAs will be reviewed and approved by the TRC Project Manager and OSC. JSA forms can be found in **Appendix I**.

19. Acknowledgement

All TRC personnel operating under this HASP must read the HASP and sign the acknowledgment page in **Appendix J**.

Figure 1
Site Layout



LEGEND

- STORMWATER CATCH BASIN
- SUMP
- STORMWATER OUTFALL 2
- PROPOSED SURFACE WATER SAMPLE
- PROPOSED INDOOR AIR SAMPLE
- BEDROCK MONITORING WELL
- OVERBURDEN MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL
- PROPOSED MONITORING WELL
- PIEZOMETER
- APPROXIMATE SANITARY SEWER
- 1,2,3 - PROPOSED STORM SEWER LINE INSPECTION
- NWI WETLANDS
- NYSDEC CLASSIFIED STREAM
- NHD FLOWLINE
- WESTCHESTER COUNTY TAX PARCEL BOUNDARIES
- FARRAND CONTROLS COUNTY TAX PARCEL BOUNDARY

NOTES:

1. LOCATIONS AND DIMENSIONS OF PHYSICAL FEATURES AND BOUNDARIES ARE APPROXIMATE.
2. BASE MAP FROM NEARMAP IMAGERY DATED APRIL 13, 2022.
3. SITE DATA AND FEATURES ARE FROM THE FARRAND CONTROLS SITE ENVIRONMENTAL SAMPLING PROGRAM REPORT BY DVIRKA AND BARTILUCCI CONSULTING ENGINEERS (2015).
4. WELL DESIGNATIONS FOR WELLS SCREENED IN OVERBURDEN, BEDROCK, AND WEATHERED BEDROCK ARE BASED ON TRC'S EVALUATION OF AVAILABLE LOGS. WHERE LOGS ARE NOT AVAILABLE, DESIGNATIONS ARE BASED ON THE FOLLOWING WELL NOMENCLATURE:

   S = SHALLOW OVERBURDEN
   D = DEEP OVERBURDEN
   R = BEDROCK

5. NWI WETLANDS ARE FROM USFWS NWI; NYSDEC CLASSIFIED STREAM IS FROM NYSDEC; NHD FLOWLINE IS FROM USDS NSD.
6. NO NYSDEC WETLANDS EXIST WITHIN MAP EXTENT.

1:1,800

1" = 150'   SHEET SIZE: 11X17L

0   75   150 FEET

PROJECT:
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
FARRAND CONTROLS - SITE NO. 360046
99 WALL STREET
VALHALLA, NEW YORK 10595

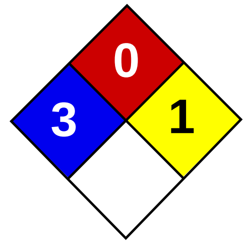
TITLE:
SITE LAYOUT MAP

DRAWN BY:	L. LILL	PROJ. NO.:	489357.0000.0000
CHECKED BY:	S. KOTA	FIGURE 1	
APPROVED BY:	J. MAGDA		
DATE:	FEBRUARY 2023		

TRC
3 Corporate Drive
Suite 202
Clifton Park, NY 12065
Phone: 518-348-1190

FILE: farrand_controls.aprx

Appendix A
Safety Data Sheets



Health	3
Fire	0
Reactivity	1
Personal Protection	

Material Safety Data Sheet
Hydrochloric acid MSDS

Section 1: Chemical Product and Company Identification

Product Name: Hydrochloric acid

Catalog Codes: SLH1462, SLH3154

CAS#: Mixture.

RTECS: MW4025000

TSCA: TSCA 8(b) inventory: Hydrochloric acid

CI#: Not applicable.

Synonym: Hydrochloric Acid; Muriatic Acid

Chemical Name: Not applicable.

Chemical Formula: Not applicable.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Hydrogen chloride	7647-01-0	20-38
Water	7732-18-5	62-80

Toxicological Data on Ingredients: Hydrogen chloride: GAS (LC50): Acute: 4701 ppm 0.5 hours [Rat].

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, . Slightly hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth. Repeated or prolonged exposure to the substance can produce target

organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used.Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: of metals

Explosion Hazards in Presence of Various Substances: Non-explosive in presence of open flames and sparks, of shocks.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards:
Non combustible. Calcium carbide reacts with hydrogen chloride gas with incandescence. Uranium phosphide reacts with hydrochloric acid to release spontaneously flammable phosphine. Rubidium acetylene carbides burns with slightly warm hydrochloric acid. Lithium silicide in contact with hydrogen chloride becomes incandescent. When dilute hydrochloric acid is used, gas spontaneously flammable in air is evolved. Magnesium boride treated with concentrated hydrochloric acid produces spontaneously flammble gas. Cesium acetylene carbide burns hydrogen chloride gas. Cesium carbide ignites in contact with hydrochloric acid unless acid is dilute. Reacts with most metals to produce flammable Hydrodgen gas.

Special Remarks on Explosion Hazards:

Hydrogen chloride in contact with the following can cause an explosion, ignition on contact, or other violent/vigorous reaction: Acetic anhydride AgClO + CCl4 Alcohols + hydrogen cyanide, Aluminum Aluminum-titanium alloys (with HCl vapor), 2-Amino ethanol, Ammonium hydroxide, Calcium carbide Ca3P2 Chlorine + dinitroanilines (evolves gas), Chlorosulfonic acid Cesium carbide Cesium acetylene carbide, 1,1-Difluoroethylene Ethylene diamine Ethylene imine, Fluorine, HClO4 Hexalithium disilicide H2SO4 Metal acetylides or carbides, Magnesium boride, Mercuric sulfate, Oleum, Potassium permanganate, beta-Propiolactone Propylene oxide Rubidium carbide, Rubidium, acetylene carbide Sodium (with aqueous HCl), Sodium hydroxide Sodium tetraselenium, Sulfonic acid, Tetraselenium tetranitride, U3P4 , Vinyl acetate. Silver perchlorate with carbon tetrachloride in the presence of hydrochloric acid produces trichloromethyl perchlorate which detonates at 40 deg. C.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep container dry. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, organic materials, metals, alkalis, moisture. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
CEIL: 5 (ppm) from OSHA (PEL) [United States] CEIL: 7 (mg/m3) from OSHA (PEL) [United States] CEIL: 5 from NIOSH CEIL: 7 (mg/m3) from NIOSH TWA: 1 STEL: 5 (ppm) [United Kingdom (UK)] TWA: 2 STEL: 8 (mg/m3) [United Kingdom (UK)]Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid.

Odor: Pungent. Irritating (Strong.)

Taste: Not available.

Molecular Weight: Not applicable.

Color: Colorless to light yellow.

pH (1% soln/water): Acidic.

Boiling Point:
108.58 C @ 760 mm Hg (for 20.22% HCl in water) 83 C @ 760 mm Hg (for 31% HCl in water) 50.5 C (for 37% HCl in water)

Melting Point:
-62.25°C (-80°F) (20.69% HCl in water) -46.2 C (31.24% HCl in water) -25.4 C (39.17% HCl in water)

Critical Temperature: Not available.

Specific Gravity:
1.1- 1.19 (Water = 1) 1.10 (20%and 22% HCl solutions) 1.12 (24% HCl solution) 1.15 (29.57% HCl solution) 1.16 (32% HCl solution) 1.19 (37% and 38%HCl solutions)

Vapor Pressure: 16 kPa (@ 20°C) average

Vapor Density: 1.267 (Air = 1)

Volatility: Not available.

Odor Threshold: 0.25 to 10 ppm

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, diethyl ether.

Solubility: Soluble in cold water, hot water, diethyl ether.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, water

Incompatibility with various substances:
Highly reactive with metals. Reactive with oxidizing agents, organic materials, alkalis, water.

Corrosivity:
Extremely corrosive in presence of aluminum, of copper, of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts with water especially when water is added to the product. Absorption of gaseous hydrogen chloride on mercuric sulfate becomes violent @ 125 deg. C. Sodium reacts very violently with gaseous hydrogen chloride. Calcium phosphide and hydrochloric acid undergo very energetic reaction. It reacts with oxidizers releasing chlorine gas. Incompatible with, alkali metals, carbides, borides, metal oxides, vinyl acetate, acetylides, sulphides, phosphides, cyanides, carbonates. Reacts with most metals to produce flammable Hydrogen gas. Reacts violently (moderate reaction with heat of evolution) with water especially when water is added to the product. Isolate hydrogen chloride from heat, direct sunlight, alkalies (reacts vigorously), organic materials, and oxidizers (especially nitric acid and chlorates), amines, metals, copper and alloys (e.g. brass), hydroxides, zinc (galvanized materials), lithium silicide (incandescence), sulfuric acid(increase in temperature and pressure) Hydrogen chloride gas is emitted when this product is in contact with sulfuric acid. Adsorption of Hydrochloric Acid onto silicon dioxide results in exothmeric reaction. Hydrogen chloride causes aldehydes and epoxides to violently polymerize. Hydrogen chloride or Hydrochloric Acid in contact with the folloiwng can cause explosion or ignition on contact or

Special Remarks on Corrosivity:

Highly corrosive. Incompatible with copper and copper alloys. It attacks nearly all metals (mercury, gold, platinium, tantalum, silver, and certain alloys are exceptions). It is one of the most corrosive of the nonoxidizing acids in contact with copper alloys. No corrosivity data on zinc, steel. Severe Corrosive effect on brass and bronze

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Dermal contact. Eye contact. Inhalation.

Toxicity to Animals:
Acute oral toxicity (LD50): 900 mg/kg [Rabbit]. Acute toxicity of the vapor (LC50): 1108 ppm, 1 hours [Mouse]. Acute toxicity of the vapor (LC50): 3124 ppm, 1 hours [Rat].

Chronic Effects on Humans:
CARCINOGENIC EFFECTS: Classified 3 (Not classifiable for human.) by IARC [Hydrochloric acid]. May cause damage to the following organs: kidneys, liver, mucous membranes, upper respiratory tract, skin, eyes, Circulatory System, teeth.

Other Toxic Effects on Humans:
Very hazardous in case of skin contact (corrosive, irritant, permeator), of ingestion, . Hazardous in case of eye contact (corrosive), of inhalation (lung corrosive).

Special Remarks on Toxicity to Animals:
Lowest Published Lethal Doses (LDL/LCL) LDL [Man] -Route: Oral; 2857 ug/kg LCL [Human] - Route: Inhalation; Dose: 1300 ppm/30M LCL [Rabbit] - Route: Inhalation; Dose: 4413 ppm/30M

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (fetoxicity). May affect genetic material.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Corrosive. Causes severe skin irritation and burns. Eyes: Corrosive. Causes severe eye irritation/conjuntivitis, burns, corneal necrosis. Inhalation: May be fatal if inhaled. Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Inhalation of hydrochloric acid fumes produces nose, throat, and larryngeal burning, and irritation, pain and inflammation, coughing, sneezing, choking sensation, hoarseness, laryngeal spasms, upper respiratory tract edema, chest pains, as well has headache, and palpitations. Inhalation of high concentrations can result in corrosive burns, necrosis of bronchial epithelium, constriction of the larynx and bronchi, nasospetal perforation, glottal closure, occur, particularly if exposure is prolonged. May affect the liver. Ingestion: May be fatal if swallowed. Causes irritation and burning, ulceration, or perforation of the gastrointestinal tract and resultant peritonitis, gastric hemorrhage and infection. Can also cause nausea, vomitting (with "coffee ground" emesis), diarrhea, thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (esophogeal, gastric, pyloric). May affect behavior (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system (kidneys- renal failure, nephritis). Acute exposure via inhalation or ingestion can also cause erosion of tooth enamel. Chronic Potential Health Effects: dyspnea, bronchitis. Chemical pneumonitis and pulmonary edema can also

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are less toxic than the product itself.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Class 8: Corrosive material

Identification: : Hydrochloric acid, solution UNNA: 1789 PG: II

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Hydrochloric acid Illinois toxic substances disclosure to employee act: Hydrochloric acid Illinois chemical safety act: Hydrochloric acid New York release reporting list: Hydrochloric acid Rhode Island RTK hazardous substances: Hydrochloric acid Pennsylvania RTK: Hydrochloric acid Minnesota: Hydrochloric acid Massachusetts RTK: Hydrochloric acid Massachusetts spill list: Hydrochloric acid New Jersey: Hydrochloric acid New Jersey spill list: Hydrochloric acid Louisiana RTK reporting list: Hydrochloric acid Louisiana spill reporting: Hydrochloric acid California Director's List of Hazardous Substances: Hydrochloric acid TSCA 8(b) inventory: Hydrochloric acid TSCA 4(a) proposed test rules: Hydrochloric acid SARA 302/304/311/312 extremely hazardous substances: Hydrochloric acid SARA 313 toxic chemical notification and release reporting: Hydrochloric acid CERCLA: Hazardous substances.: Hydrochloric acid: 5000 lbs. (2268 kg)

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.

DSCL (EEC):
R34- Causes burns. R37- Irritating to respiratory system. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 0

Reactivity: 1

Personal Protection:

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 0

Reactivity: 1

Specific hazard:

Protective Equipment:
Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II. -Guide de la loi et du règlement sur le transport des marchandises dangeureuses au canada. Centre de conformité internatinal Ltée. 1986.

Other Special Considerations: Not available.

Created: 10/09/2005 05:45 PM

Last Updated: 06/09/2012 12:00 PM

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

MSDS NO: 248 **Version:3** **Date: August, 2010**

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1. Chemical Product and Company Identification

Gasco Affiliates, LLC
320 Scarlett Blvd.
Oldsmar, FL 34677

TELEPHONE NUMBER: (800) 910-0051 **24-HOUR EMERGENCY NUMBER: 1-800-424-9300**
FAX NUMBER: (866) 755-8920
E-MAIL: info@gascogas.com

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR
CHEMICAL NAME: Isobutylene in air
COMMON NAMES/ SYNONYMS: None
TDG (Canada) CLASSIFICATION: 2.2
WHIMIS CLASSIFICATION: A

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2. COMPOSITION/ INFORMATION ON INGREDIENTS

INGREDIENT	%VOLUME	PEL-OSHA	TLV-ACGIH	LD_{50} or LC_{50} Route/Species
Isobutylene FORMULA: C_4H_8	0.0001-0.9	N/A	N/A	N/A
Air FORMULA: Mixture	99.0 to 99.9999	N/A	N/A	N/A

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3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Release of this product may produce oxygen-deficient atmospheres (especially in confined spaces or other poorly ventilated environments); individuals in such atmospheres may be asphyxiated. Isobutylene may cause drowsiness and other central nervous system effects in high concentrations; however, due to the low concentration of this gas mixture, this is unlikely to occur.

ROUTE OF ENTRY:

Skin Contact	Skin Absorption	Eye Contact	Inhalation	Ingestion
No	No	No	Yes	No

HEALTH EFFECTS:

Exposure Limits	Irritant	Sensitization	Reproductive Hazard	Mutagen
Yes	No	No	No	No

Carcinogenicity: --NTP: No IARC: No OSHA: No

EYE EFFECTS:
N/A.

SKIN EFFECTS:
N/A.

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

INGESTION EFFECTS:
Ingestion unlikely. Gas at room temperature.

INHALATION EFFECTS:
Due to the small size of this cylinder, no unusual health effects from over-exposure are anticipated under normal routine use.

NFPA HAZARD CODES		HMIS HAZARD CODES		RATING SYSTEM
Health:	1	Health:	1	0= No Hazard
Flammability:	0	Flammability:	0	1= Slight Hazard
Reactivity:	0	Reactivity:	0	2= Moderate Hazard
				3= Serious Hazard
				4= Severe Hazard

4. FIRST AID MEASURES

EYES:
N/A

SKIN:
N/A

INGESTION:
Not required

INHALATION:
PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASED OF OVEREXPOSURE. RESCUE PERSONNEL SHOULD BE EQUIPPED THE SELF-CONTAINED BREATHING APPARATUS. Victims should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. If breathing has stopped administer artificial resuscitation and supplemental oxygen. Further treatment should be symptomatic and supportive.

5. FIRE-FIGHTING MEASURES

These containers hold gas under pressure, with no liquid phase. If involved in a major fire, they should be sprayed with water to avoid pressure increases, otherwise pressures will rise and ultimately they may distort or burst to release the contents. The gases will not add significantly to the fire, but containers or fragments may be projected considerable distances - thereby hampering fire fighting efforts.

6. ACCIDENTAL RELEASE MEASURES

In terms of weight, these containers hold very little contents, such that any accidental release by puncturing etc. will be of no practical concern.

7. HANDLING AND STORAGE

Suck back of water into the container must be prevented. Do not allow backfeed into the container. Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Use only in well-ventilated areas. Do not heat cylinder by any means to increase rate of product from the cylinder. Do not allow the temperature where cylinders are stored to exceed 130^{o}F (54^{o}C).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Use adequate ventilation for extended use of gas.

MATERIAL SAFETY DATA SHEET - CALIBRATION CHECK GAS

PRODUCT NAME: ISOBUTYLENE (1 PPM – 0.9%) IN AIR

9. PHYSICAL AND CHEMICAL PROPERTIES

PARAMETER:	VALUE:
Physical state	: Gas
Evaporation point	: N/A
pH	: N/A
Odor and appearance	: Colorless, odorless gas

10. STABILITY AND REACTIVITY

Stable under normal conditions. Expected shelf life 48 months.

11. TOXICOLOGICAL INFORMATION

No toxicological damage caused by this product.

12. ECOLOGICAL INFORMATION

No ecological damage caused by this product.

13. DISPOSAL INFORMATION

Do not discharge into any place where its accumulation could be dangerous. Used containers are acceptable for disposal in the normal waste stream as long as the cylinder is empty and valve removed or cylinder wall is punctured; but GASCO encourages the consumer to return cylinders.

14. TRANSPORT INFORMATION

	United States DOT	Canada TDG
PROPER SHIPPING NAME:	Compressed Gas N.O.S. (Isobutylene in Air)	Compressed Gas N.O.S. (Isobutylene in Air)
HAZARD CLASS:	2.2	2.2
IDENTIFICATION NUMBER:	UN1956	UN1956
SHIPPING LABEL:	NONFLAMMABLE GAS	NONFLAMMABLE GAS

15. REGULATORY INFORMATION

Isobutylene is listed under the accident prevention provisions of section 112(r) of the Clean Air Act (CAA) with a threshold quantity (TQ) of 10,000 pounds.

16. OTHER INFORMATION

This MSDS has been prepared in accordance with the Chemicals (Hazard Information and Packaging for Supply (Amendment) Regulation 1996. The information is based on the best knowledge of GASCO, and its advisors and is given in good faith, but we cannot guarantee its accuracy, reliability or completeness and therefore disclaim any liability for loss or damage arising out of use of this data. Since conditions of use are outside the control of the Company and its advisors we disclaim any liability for loss or damage when the product is used for other purposes than it is intended.

MSDS/S010/248/ August, 2010

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017

Trade Name: Alconox

1 Identification of the substance/mixture and of the supplier

1.1 Product identifier

Trade Name: Alconox
Synonyms:
Product number: 1104-1, 1104, 1125, 1150, 1101, 1103, 1112-1, 1112

1.2 Application of the substance / the mixture : Cleaning material/Detergent

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer **Supplier**

Alconox, Inc.
30 Glenn Street
White Plains, NY 10603
1-914-948-4040

Emergency telephone number:
ChemTel Inc
North America: 1-800-255-3924
International: 01-813-248-0585

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments.

Hazard-determining components of labeling:

Tetrasodium Pyrophosphate
Sodium tripolyphosphate
Sodium Alkylbenzene Sulfonate

2.2 Label elements:

Skin irritation, category 2.
Eye irritation, category 2A.

Hazard pictograms:

Signal word: Warning

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P321 Specific treatment (see supplemental first aid instructions on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P501 Dispose of contents and container as instructed in Section 13.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017
Trade Name: Alconox

Additional information: None.

Hazard description
Hazards Not Otherwise Classified (HNOC): None

Information concerning particular hazards for humans and environment:
The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:
The classification is according to EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments, and extended by company and literature data. The classification is in accordance with the latest editions of international substances lists, and is supplemented by information from technical literature and by information provided by the company.

3 Composition/information on ingredients

3.1 Chemical characterization : None

3.2 Description : None

3.3 Hazardous components (percentages by weight)

Identification	Chemical Name	Classification	Wt. %
CAS number: 7758-29-4	Sodium tripolyphosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	12-28
CAS number: 68081-81-2	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	8-22
CAS number: 7722-88-5	Tetrasodium Pyrophosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	2-16

3.4 Additional Information : None.

4 First aid measures

4.1 Description of first aid measures

General information: None.

After inhalation:
Maintain an unobstructed airway.
Loosen clothing as necessary and position individual in a comfortable position.

After skin contact:
Wash affected area with soap and water.
Seek medical attention if symptoms develop or persist.

After eye contact:
Rinse/flush exposed eye(s) gently using water for 15-20 minutes.
Remove contact lens(es) if able to do so during rinsing.
Seek medical attention if irritation persists or if concerned.

After swallowing:
Rinse mouth thoroughly.
Seek medical attention if irritation, discomfort, or vomiting persists.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017

Trade Name: Alconox

4.2 Most important symptoms and effects, both acute and delayed

None

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information.

5 Firefighting measures

5.1 Extinguishing media

Suitable extinguishing agents:

Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition.

For safety reasons unsuitable extinguishing agents : None

5.2 Special hazards arising from the substance or mixture :

Thermal decomposition can lead to release of irritating gases and vapors.

5.3 Advice for firefighters

Protective equipment:

Wear protective eye wear, gloves and clothing.
Refer to Section 8.

5.4 Additional information :

Avoid inhaling gases, fumes, dust, mist, vapor and aerosols.
Avoid contact with skin, eyes and clothing.

6 Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures :

Ensure adequate ventilation.
Ensure air handling systems are operational.

6.2 Environmental precautions :

Should not be released into the environment.
Prevent from reaching drains, sewer or waterway.

6.3 Methods and material for containment and cleaning up :

Wear protective eye wear, gloves and clothing.

6.4 Reference to other sections : None

7 Handling and storage

7.1 Precautions for safe handling :

Avoid breathing mist or vapor.
Do not eat, drink, smoke or use personal products when handling chemical substances.

7.2 Conditions for safe storage, including any incompatibilities :

Store in a cool, well-ventilated area.

7.3 Specific end use(s):

No additional information.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017
Trade Name: Alconox

8 Exposure controls/personal protection

8.1 Control parameters :

a) 7722-88-5, Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3
b) Dusts, non-specific OEL, Irish Code of Practice
   (i) Total inhalable 10 mg/m3 (8hr)
   (ii) Respirible 4mg/m3 (8hr)
   (iii) Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3, (8hr)

8.2 Exposure controls

Appropriate engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use or handling.

Respiratory protection:

Not needed under normal use conditions.

Protection of skin:

Select glove material impermeable and resistant to the substance or preparation. Protective gloves recommended to comply with EN 374. Take note of break through times, permeability, and special workplace conditions, such as mechanical strain, duration of contact, etc. Protective gloves should be replaced at the first sign of wear.

Eye protection:

Safety goggles or glasses, or appropriate eye protection. Recommended to comply with ANSI Z87.1 and/or EN 166.

General hygienic measures:

Wash hands before breaks and at the end of work.
Avoid contact with skin, eyes and clothing.

9 Physical and chemical properties

Appearance (physical state, color):	White and cream colored flakes - powder	**Explosion limit lower**: **Explosion limit upper**:	Not determined or not available. Not determined or not available.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or not available.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or not available.
pH-value:	9.5 (aqueous solution)	**Relative density**:	Not determined or not available.
Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or not available.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or not available.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or not available.
Evaporation rate:	Not determined or not available.	**Decompositio n**	Not determined or not available.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017
Trade Name: Alconox

Flammability (solid, gaseous):	Not determined or not available.	**Viscosity**:	a. Kinematic: Not determined or not available. b. Dynamic: Not determined or not available.
Density at 20°C:	Not determined or not available.		

10 Stability and reactivity

10.1 Reactivity : None

10.2 Chemical stability : None

10.3 Possibility hazardous reactions : None

10.4 Conditions to avoid : None

10.5 Incompatible materials : None

10.6 Hazardous decomposition products : None

11 Toxicological information

11.1 Information on toxicological effects :

Acute Toxicity:

Oral:

: LD50 > 5000 mg/kg oral rat - Product .

Chronic Toxicity: No additional information.

Skin corrosion/irritation:

Sodium Alkylbenzene Sulfonate: Causes skin irritation. .

Serious eye damage/irritation:

Sodium Alkylbenzene Sulfonate: Causes serious eye irritation .

Tetrasodium Pyrophosphate: Rabbit - Risk of serious damage to eyes .

Respiratory or skin sensitization: No additional information.

Carcinogenicity: No additional information.

IARC (International Agency for Research on Cancer): None of the ingredients are listed.

NTP (National Toxicology Program): None of the ingredients are listed.

Germ cell mutagenicity: No additional information.

Reproductive toxicity: No additional information.

STOT-single and repeated exposure: No additional information.

Additional toxicological information: No additional information.

12 Ecological information

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.
Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.4 mg/l, 48 hours. Sodium Alkylbenzene Sulfonate: Aquatic Plants, EC50 Algae 29 mg/l, 96 hours.
Tetrasodium Pyrophosphate: Fish, LC50 - other fish - 1,380 mg/l - 96 h.
Tetrasodium Pyrophosphate: Aquatic invertebrates, EC50 - Daphnia magna (Water flea) - 391 mg/l - 48 h.

12.2 Persistence and degradability: No additional information.

12.3 Bioaccumulative potential: No additional information.

12.4 Mobility in soil: No additional information.

General notes: No additional information.

12.5 Results of PBT and vPvB assessment:

PBT: No additional information.

vPvB: No additional information.

12.6 Other adverse effects: No additional information.

13 Disposal considerations

13.1 Waste treatment methods (consult local, regional and national authorities for proper disposal)

Relevant Information:

It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities. (US 40CFR262.11).

14 Transport information

14.1 UN Number: None
ADR, ADN, DOT, IMDG, IATA

14.2 UN Proper shipping name: None
ADR, ADN, DOT, IMDG, IATA

14.3 Transport hazard classes:
ADR, ADN, DOT, IMDG, IATA

Class: None
Label: None
LTD. QTY: None

US DOT
Limited Quantity Exception: None

Bulk:	**Non Bulk:**
RQ (if applicable): None	**RQ (if applicable):** None
Proper shipping Name: None	**Proper shipping Name:** None
Hazard Class: None	**Hazard Class:** None
Packing Group: None	**Packing Group:** None
Marine Pollutant (if applicable): No additional information.	**Marine Pollutant (if applicable):** No additional information.

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 10.18.2017 **Revision**: 10.18.2017
Trade Name: Alconox

	Comments: None	**Comments:** None
14.4	**Packing group:** ADR, ADN, DOT, IMDG, IATA	None
14.5	**Environmental hazards** :	None
14.6	**Special precautions for user:**	None
	Danger code (Kemler):	None
	EMS number:	None
	Segregation groups:	None
14.7	**Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code:** Not applicable.	
14.8	**Transport/Additional information:**	
	Transport category:	None
	Tunnel restriction code:	None
	UN "Model Regulation":	None

15 Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture.

North American

SARA

Section 313 (specific toxic chemical listings): None of the ingredients are listed.
Section 302 (extremely hazardous substances): None of the ingredients are listed.

CERCLA (Comprehensive Environmental Response, Clean up and Liability Act) Reportable Spill Quantity: None of the ingredients are listed.

TSCA (Toxic Substances Control Act):

Inventory: All ingredients are listed.
Rules and Orders: Not applicable.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredients are listed.

Chemicals known to cause developmental toxicity: None of the ingredients are listed.

Canadian

Canadian Domestic Substances List (DSL):
All ingredients are listed.

EU

REACH Article 57 (SVHC): None of the ingredients are listed.

Germany MAK: Not classified.

EC 648/2004 – This is an industrial detergent. Contains >30% phosphate, 15-30% anionic surfactant, <5% EDTA salts

EC 551/2009 – This is not a laundry or dishwasher detergent

EC 907/2006 – Contains no enzymes, optical brighteners, perfumes, allergenic fragrances, or preservative agents

Asia Pacific

Australia

Australian Inventory of Chemical Substances (AICS): All ingredients are listed.

China

Inventory of Existing Chemical Substances in China (IECSC): All ingredients are listed.

Japan

Inventory of Existing and New Chemical Substances (ENCS): All ingredients are listed.

Korea

Existing Chemicals List (ECL): All ingredients are listed.

New Zealand

New Zealand Inventory of Chemicals (NZOIC): All ingredients are listed.

Philippines

Philippine Inventory of Chemicals and Chemical Substances (PICCS): All ingredients are listed.

Taiwan

Taiwan Chemical Substance Inventory (TSCI): All ingredients are listed.

16 Other information

Abbreviations and Acronyms: None

Summary of Phrases

Hazard statements:

H315 Causes skin irritation.

H319 Causes serious eye irritation.

NFPA: 1-0-0

HMIS: 1-0-0

Precautionary statements:

P264 Wash skin thoroughly after handling.

P280 Wear protective gloves/protective clothing/eye protection/face protection.

P302+P352 If on skin: Wash with soap and water.

P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.

P321 Specific treatment (see supplemental first aid instructions on this label).

P332+P313 If skin irritation occurs: Get medical advice/attention.

P362 Take off contaminated clothing and wash before reuse.

P501 Dispose of contents and container as instructed in Section 13.

Manufacturer Statement:

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

1 Identification of the substance/mixture and of the supplier

1.1 Product identifier

Trade Name: Liquinox
Synonyms:
Product number: 1232-1, 1232, 1201-1, 1201, 1205, 1215, 1255

1.2 Application of the substance / the mixture : Cleaning material/Detergent

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer **Supplier**

Alconox, Inc.
30 Glenn Street
White Plains, NY 10603
1-914-948-4040

Emergency telephone number:

ChemTel Inc
North America: 1-800-255-3924
International: 01-813-248-0585

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments.

Hazard-determining components of labeling:

Alcohol ethoxylate
Sodium alkylbenzene sulfonate
Sodium xylenesulphonate
Lauramine oxide

2.2 Label elements:

Eye irritation, category 2A.
Skin irritation, category 2.

Hazard pictograms:

Signal word: Warning

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P332+P313 If skin irritation occurs: Get medical advice/attention.
P501 Dispose of contents and container as instructed in Section 13.

Additional information: None.

Hazard description

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Trade Name: Liquinox

Hazards Not Otherwise Classified (HNOC): None

Information concerning particular hazards for humans and environment:

The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:

The classification is according to EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments, and extended by company and literature data. The classification is in accordance with the latest editions of international substances lists, and is supplemented by information from technical literature and by information provided by the company.

3 Composition/information on ingredients

3.1 Chemical characterization : None

3.2 Description : None

3.3 Hazardous components (percentages by weight)

Identification	Chemical Name	Classification	Wt. %
CAS number: 68081-81-2	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	10-25
CAS number: 1300-72-7	Sodium Xylenesulphonate	Eye Irrit. 2; H319	2.5-10
CAS number: 84133-50-6	Alcohol Ethoxylate	Skin Irrit. 2 ; H315 Eye Dam. 1; H318	2.5-10
CAS number: 1643-20-5	Lauramine oxide	Skin Irrit. 2 ; H315 Eye Dam. 1; H318	1-2

3.4 Additional Information: None.

4 First aid measures

4.1 Description of first aid measures

General information: None.

After inhalation:

Maintain an unobstructed airway.
Loosen clothing as necessary and position individual in a comfortable position.

After skin contact:

Wash affected area with soap and water.
Seek medical attention if symptoms develop or persist.

After eye contact:

Rinse/flush exposed eye(s) gently using water for 15-20 minutes.

Remove contact lens(es) if able to do so during rinsing.
Seek medical attention if irritation persists or if concerned.

After swallowing:

Rinse mouth thoroughly.
Seek medical attention if irritation, discomfort, or vomiting persists.

4.2 Most important symptoms and effects, both acute and delayed

None

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Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information.

5 Firefighting measures

5.1 Extinguishing media

Suitable extinguishing agents:

Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition.

For safety reasons unsuitable extinguishing agents : None

5.2 Special hazards arising from the substance or mixture :

Thermal decomposition can lead to release of irritating gases and vapors.

5.3 Advice for firefighters

Protective equipment:

Wear protective eye wear, gloves and clothing.
Refer to Section 8.

5.4 Additional information :

Avoid inhaling gases, fumes, dust, mist, vapor and aerosols.
Avoid contact with skin, eyes and clothing.

6 Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures :

Ensure adequate ventilation.
Ensure air handling systems are operational.

6.2 Environmental precautions :

Should not be released into the environment.
Prevent from reaching drains, sewer or waterway.

6.3 Methods and material for containment and cleaning up :

Wear protective eye wear, gloves and clothing.

6.4 Reference to other sections : None

7 Handling and storage

7.1 Precautions for safe handling :

Avoid breathing mist or vapor.
Do not eat, drink, smoke or use personal products when handling chemical substances.
Conditions for safe storage, including any incompatibilities:
Store closed upright and in a cool dry place, should be 15 - 30 deg C or 60 - 90 deg F.

7.2 Specific end use(s):

No additional information.

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Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

8 Exposure controls/personal protection

8.1 Control parameters :

No applicable occupational exposure limits

8.2 Exposure controls

Appropriate engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use or handling.

Respiratory protection:

Not needed under normal conditions.

Protection of skin:

Select glove material impermeable and resistant to the substance.

Eye protection:

Safety goggles or glasses, or appropriate eye protection.

General hygienic measures:

Wash hands before breaks and at the end of work.
Avoid contact with skin, eyes and clothing.

9 Physical and chemical properties

Appearance (physical state, color):	Pale yellow liquid	**Explosion limit lower**: **Explosion limit upper**:	Not determined or not available. Not determined or not available.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or not available.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or not available.
pH-value:	8.5 as is	**Relative density**:	Not determined or not available.
Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or not available.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or not available.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or not available.
Evaporation rate:	Not determined or not available.	**Decomposition temperature**:	Not determined or not available.
Flammability (solid, gaseous):	Not determined or not available.	**Viscosity**:	a. Kinematic: Not determined or not available. b. Dynamic: Not determined or not available.

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Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox	
Density at 20°C:	Not determined or not available.

10 Stability and reactivity

10.1 Reactivity : None

10.2 Chemical stability : None

10.3 Possibility hazardous reactions : None

10.4 Conditions to avoid : None

10.5 Incompatible materials : None

10.6 Hazardous decomposition products : None

11 Toxicological information

11.1 Information on toxicological effects :

Acute Toxicity:

Oral:

: LD50 >5000 mg per kg Rat, Oral) - product .

Chronic Toxicity: No additional information.

Skin corrosion/irritation:

Alcohol Ethoxylate: May cause mild to moderate skin irritation.

Sodium Alkylbenzene Sulfonate: Causes skin irritation.

Lauramine oxide: Causes skin irritation.

Serious eye damage/irritation:

Sodium Alkylbenzene Sulfonate: Causes serious eye irritation.

Alcohol Ethoxylate: Causes moderate to severe eye irritation and conjunctivitis.

Sodium xylenesulphonate: Rabbit: irritating to eyes.

Lauramine oxide: Causes serious eye damage.

Respiratory or skin sensitization: No additional information.

Carcinogenicity: No additional information.

IARC (International Agency for Research on Cancer): None of the ingredients are listed.

NTP (National Toxicology Program): None of the ingredients are listed.

Germ cell mutagenicity: No additional information.

Reproductive toxicity: No additional information.

STOT-single and repeated exposure: No additional information.

Additional toxicological information: No additional information.

12 Ecological information

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.

Safety Data Sheet

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Trade Name: Liquinox

Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.4 mg/l, 48 hours.
Sodium Alkylbenzene Sulfonate: Aquatic Plants, EC50 Algae 29 mg/l, 96 hours.
Lauramine oxide: Fish, LC0 24.3 mg/l, 96h [Killifish (Cyprinodontidae)]
Lauramine oxide: Aquatic invertebrates, (LC50): 3.6 mg/l 96 hours [Daphnia (Daphnia)].
Lauramine oxide: Aquatic plants, EC50 Algae 0.31 mg/l 72 hours [Algae]
Alcohol Ethoxylate: Aquatic invertebrates, (LC50): 4.01 mg/l 48 hours [Daphnia (daphnia)].

12.2 Persistence and degradability: No additional information.

12.3 Bioaccumulative potential: No additional information.

12.4 Mobility in soil: No additional information.

General notes: No additional information.

12.5 Results of PBT and vPvB assessment:

PBT: No additional information.

vPvB: No additional information.

12.6 Other adverse effects: No additional information.

13 Disposal considerations

13.1 Waste treatment methods (consult local, regional and national authorities for proper disposal)

Relevant Information:

It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities. (US 40CFR262.11).

14 Transport information

14.1 UN Number: None
ADR, ADN, DOT, IMDG, IATA

14.2 UN Proper shipping name: None
ADR, ADN, DOT, IMDG, IATA

14.3 Transport hazard classes:
ADR, ADN, DOT, IMDG, IATA

Class: None
Label: None
LTD.QTY: None

US DOT
Limited Quantity Exception: None

Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.
Comments: None

Non Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.
Comments: None

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Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

14.4 Packing group: None
ADR, ADN, DOT, IMDG, IATA

14.5 Environmental hazards : None

14.6 Special precautions for user: None

Danger code (Kemler): None
EMS number: None
Segregation groups: None

14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code: Not applicable.

14.8 Transport/Additional information:

Transport category: None
Tunnel restriction code: None
UN "Model Regulation": None

15 Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture.

North American

SARA

Section 313 (specific toxic chemical listings): None of the ingredients are listed.
Section 302 (extremely hazardous substances): None of the ingredients are listed.

CERCLA (Comprehensive Environmental Response, Clean up and Liability Act) Reportable Spill Quantity: None of the ingredients are listed.

TSCA (Toxic Substances Control Act):

Inventory: All ingredients are listed.
Rules and Orders: Not applicable.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredients are listed.

Chemicals known to cause developmental toxicity: None of the ingredients are listed.

Canadian

Canadian Domestic Substances List (DSL):
All ingredients are listed.

EU

REACH Article 57 (SVHC): None of the ingredients are listed.

Germany MAK: Not classified.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 05/17/2017 **Revision** : 05/17/2017

Trade Name: Liquinox

Asia Pacific

Australia

Australian Inventory of Chemical Substances (AICS): All ingredients are listed.

China

Inventory of Existing Chemical Substances in China (IECSC): All ingredients are listed.

Japan

Inventory of Existing and New Chemical Substances (ENCS): All ingredients are listed.

Korea

Existing Chemicals List (ECL): All ingredients are listed.

New Zealand

New Zealand Inventory of Chemicals (NZOIC): All ingredients are listed.

Philippines

Philippine Inventory of Chemicals and Chemical Substances (PICCS): All ingredients are listed.

Taiwan

Taiwan Chemical Substance Inventory (TSCI): All ingredients are listed.

16 Other information

Abbreviations and Acronyms: None

Summary of Phrases

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P332+P313 If skin irritation occurs: Get medical advice/attention.
P501 Dispose of contents and container as instructed in Section 13.

Manufacturer Statement:

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling,

use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

NFPA: 1-0-0

HMIS: 1-0-0

Appendix B
Glove Selection Guideline

APPENDIX B: GLOVE SELECTION GUIDELINE

HAZARD	EXAMPLE TASKS	ANSI CUT/ABRASION RATING*	REPRESENTATIVE GLOVE
Impact Hazards, Med/Heavy Duty Puncture Cut	Drilling/direct push activities. Construction. Heavy materials handling. Power tools. Air knifing. Excavation.	ANSI Cut and Abrasion Resistance **Level 5** **EN 388 4521**	Hexarmor®Chrome Hexarmor® GGT5 Hexarmor® L5 Hexarmor® SteelLeather III Ironclad® Kong Glove
Med/Heavy Duty Puncture Cut Oil/Solvent Resistant	Tasks where materials are treated with oil or solvents.	ANSI Cut and Abrasion Resistance **Level 3 - 4** **EN 388 4522**	Ansell Alpha-Tec ® Memphis® Ultra Tech Nitrile Cut & Splash Best® Neoprene 6780 Hexarmor™ TenX Threesixty
Medium Duty Cut/Puncture Gloves with Oily Surface Grip	Light materials handling, wet service	ANSI Cut and Abrasion Resistance **Level 3** **EN 388 44xx**	Best®Zorb-It Ultimate HV 4567 Ansell® Cut Protective Glove 97-505 Ansell HyFlex® 11-511 Ansell HyFlex® 11-624
Med/Heavy Duty Cut/Puncture	Light Materials Handling. System O&M. Use of Hand Tools. Hand Augering. Heavy Equipment Operator.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 33xx**	Perfect Fit® PF570 Hexarmor® Level Six 9010/9012 Ironclad® Cut Resistant Glove Ansell HyFlex® 11-511 Ansell HyFlex® 11-624 Ansell® Cut Protective Glove 97-505
Light Duty Cut/Puncture Abrasion Only	Handling soil and Groundwater Samples. Opening spoons. Well construction.	ANSI Cut and Abrasion Resistance **Level 2 - 4** **EN 388 21xx**	Memphis® Ninja Max N9676GL Memphis® UltraTech Dyneema 9676 Memphis® Ninja Ice (Cold Weather) Ansell HyFlex® 11-511 Ansell® Cut Protective Glove 97-505 Ansell® Powerflex 80-813 Ironclad™ Workforce
Light Duty Glove Cut/Abrasion (used under nitrile gloves)	Groundwater Sampling.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 21xx**	Ansell HyFlex® 11-500 Ansell HyFlex® 11-624 Ansell GoldKnit

* Reference to ANSI and EN 388 glove testing standards. Listed gloves meet the standards in the table, but are not the only gloves that meet the standard.

This selection chart is not intended to address all chemical hazards. Gloves used for chemical protection shall provide cut/puncture resistance, or be used in tandem with cut/puncture protection. Nitrile gloves used for environmental sampling must be used in tandem with a cut/puncture resistant glove.

Gloves available in high visibility colors have shown to be effective and are preferred.

Appendix C
Excavation Hazard Recognition Guide (Trenching/Shoring), Site Assessment Questions, and Related Guidance

1. PURPOSE

TRC's Trench and Excavation Compliance Program has been developed based on the Occupational Safety and Health Administration (OSHA) standards for the construction industry (29 CFR 1926, Subpart P – Excavations).

2. SCOPE

This Compliance Program applies to all open excavations made in the earth's surface. Excavations are defined to include trenches. These guidelines apply to all Operating Unit facilities and project sites.

3. DEFINITIONS

<u>Accepted engineering practices</u>: Those requirements which are compatible with standards of practice required by a registered professional engineer.

<u>Aluminum Hydraulic Shoring</u>: A pre-engineered shoring system comprised of aluminum hydraulic cylinders (cross braces) used in conjunction with vertical rails (uprights) or horizontal rails (wales). Such system is designed specifically to support the sidewalls of an excavation and prevent cave-ins.

<u>Bell-bottom pier hole</u>: A type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

<u>Benching (Benching system)</u>: A method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

<u>Cave-in</u>: The separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

<u>Competent person</u>: One who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

<u>Cross braces</u>: The horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

<u>Excavation</u>: Any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

<u>Faces or Sides</u>: The vertical or inclined earth surfaces formed as a result of excavation work.

<u>Failure</u>: The breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere: An atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kick-out: The accidental release or failure of a cross brace.

Protective system: A method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp: An inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer: A person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting: The members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system): A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system): A structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation, and which is designed to prevent cave-ins.

Sloping (Sloping system): A method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock: Natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp: A ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system: A structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data: Tables and charts approved by a registered professional engineer, and used to design and construct a protective system.

Trench (Trench excavation): A narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box: See Shield.

Trench shield: See Shield.

Type A soil: Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of cohesive soils are clay, silty clay, sandy clay, clay loam, and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hard pan are also considered Type A. However, no soil is Type A if:

- The soil is fissured.
- The soil is subject to vibration from heavy traffic, pile driving, or similar effects.
- The soil has been previously disturbed.
- The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater.
- The material is subject to other factors that would require it to be classified as a less stable material.

Type B soil**:** Cohesive soil with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; granular cohesion less soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and in some cases, silty clay loam and sandy clay loam; previously disturbed soils except those that would otherwise be classed as Type C soil; soil that meets the unconfined compressive strength or cementation requirements for Type A but is fissured or subject to vibration; dry rock that is not stable; material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C soil: Cohesive soil with an unconfined compressive strength of 0.5 tsf or less; granular soils, including gravel, sand, and loamy sand; submerged soils, including soil from which water is freely seeping; submerged rock that is not stable; material in a sloped, layered system where the layers dip into the excavation at a slope of four horizontal to one vertical (4H:1V) or steeper.

Uprights**:** The vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales: Horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

4. RESPONSIBILITIES

4.1 TRC's National Safety Director is responsible for establishing the Trench and Excavation Program requirements and providing/communicating them to the Health and Safety Network. The National Safety Director will review contract documents as required that include project and Client-Specific Requirements.

4.2 The Health and Safety Network is responsible for the Trench and Excavation Program implementation including, but not limited to:

- Qualifying or identifying Competent Person(s) for trench and excavation safety.
- Training new and existing TRC employees.
- Communicating and coordinating TRC's Trench and Excavation Program requirements with all TRC subcontractors, including identification of Subcontractor(s) Competent Person(s).
- Procuring TRC health and safety equipment (harnesses, lanyards, vertical and horizontal lifeline and other materials).
- Working in conjunction with identified Competent Person(s) to provide on-site direction on Trench and Excavation issues.
- Leading all investigations along with the Competent Person, Project Manager, Field Team Leader, and subcontractor health and safety representative or their designees, if a Trench and Excavation Program violation occurs on-site.
- Assisting in Trench and Excavation Program audits in conjunction with on-site TRC subcontractor, and the health and safety representatives or their designees.
- Maintaining records for health and safety activities on-site including equipment inspections and procedural audits of employee Trench and Excavation Program implementation.
- Coordinating assistance during emergency situations.

4.3 OSHA defines a Competent Person as one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, who has authorization to take prompt corrective measures to eliminate them (29 CFR 1926.32[f]). By way of training and/or experience, a Competent Person is knowledgeable of applicable standards, and is capable of identifying workplace hazards related to the specific operation. Under TRC's Trench and Excavation Program the Competent Person will:

- Perform all duties as specified in the Trench and Excavation Program.

- Review and approve all Health and Safety Plans (HASPs) and Job Safety Analyses (JSAs) that include work in and around trenches and excavations.
- In the event of simultaneous operations, cooperate fully with the Subcontractor's Person in Charge.
- Communicate with performing authorities (i.e., employees working in or around trenches or excavations) regarding the presence of other operations on-site.
- Work with Project Manager and/or Field Team Leader to identify and manage the risks associated with the project site.
- Assist in the training of employees who will be performing tasks in and around a trench or excavation.
- Ensure that a rescue plan is established by working with the Project Manager and/or facility safety personnel prior to any employees entering or working around a trench or excavation.
- Provide guidance as required for Trench and Excavation Program issues and questions.
- Coordinate with Project Managers and Health and Safety Network on trench and excavation audits.
- Observe the implementation of Trench and Excavation Program and conduct audits as required or directed.

4.4 The Project Manager is responsible for assisting the Health and Safety Network in the implementation of the Trench and Excavation Program. Project Managers must hold all TRC and other project employees working on-site accountable (zero tolerance policy) for maintaining a safe work environment.

4.5 Project Managers and site employees shall be held accountable for performing work in a safe manner according to the requirements of the Trench and Excavation Program.

4.5.1 The Field Team Leader shall:

- Participate in Trench and Excavation Awareness training.
- Confirm that Competent Personnel prepared and/or reviewed the Site-Specific Rescue Plan if required.
- When required, confirm that everyone working under a specific permit adheres to the permit's documented conditions.

5. PROCEDURE

5.1 General Requirements Permit labor

The following guidelines establish the minimum requirements of the applicable state and federal safety regulations for all work in excavations and trenches that might expose employees to the hazards of moving ground:

- All surface encumbrances adjacent to an excavation that might create a hazard to employees must be removed, secured, or supported as necessary to protect employees.
- The estimated location of underground installations, such as sewer, telephone, electric, water, or other underground utilities must be identified before opening an excavation. Utility companies, owners, and local One Call locator services must be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations before the work begins.
- When excavations approach the estimated location of underground installations, the exact location is determined by probing or hand digging, as necessary, to prevent accidental contact with the underground installations. While the excavation is open, underground installations that create a hazard to employees will be supported, protected, or removed as necessary to protect employees.

5.1.1 Access and Egress - Structural ramps.

- Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.
- Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.
- Structural members used for ramps and runways shall be of uniform thickness.
- Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.
- Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments o the top surface to prevent slipping.
- Appropriate access and egress in the form of a stairway, ladder, or ramp must be provided in all excavations deeper than 4 feet (1.23 m). In trenches, the stairway, ladder, or ramp must be installed so that a worker does not have to travel farther than 25 feet (7.62 m) in any direction to exit.

- Employees exposed to vehicular traffic must wear safety vests or other equivalent apparel marked with or made of reflectorized or high-visibility material.
- No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.
- A warning system must be provided when mobile equipment is operated adjacent to an excavation and the operator does not have a clear and direct view of the edge of the excavation. The warning system may include barricades, signals, stop logs, or other authorized methods. If possible, the grade should be away from the excavation.
- When deemed necessary by a competent person, excavations where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.
- When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.
- Emergency rescue equipment, such as rescue breathing apparatus, a safety harness and line, or a basket stretcher must be available where a hazardous atmosphere exists or could be expected to develop in an excavation.
- Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.
- Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

- If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.
- Inspection of an excavation shall be made by a competent person when accumulation of water is present.
- If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person.
- The stability of adjacent structures, such as buildings, walls, and sidewalks must be maintained using a support system as necessary to protect employees.
- Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:
  - A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
  - The excavation is in stable rock; or
  - A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or
  - A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.
- Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.
- Employees must be protected from loose rock or soil that could fall or roll into the excavation by placing and keeping such material at least 2 feet (0.61 m) from the edge of the excavation.
- A competent person must make daily inspections of excavations to identify and eliminate conditions that could result in cave-ins, failure of support systems, hazardous atmospheres, or other unsafe conditions. Inspections must be conducted before the start of work each day and after every rainstorm or other occurrence that might increase the hazard of moving ground. If problems are found, provisions should be made for immediate removal of personnel.

- Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.
- Where employees or equipment are allowed or required to cross over excavations that are 6 feet
- (1.83 m) or greater in depth, appropriate fall protection in the form of walkways or bridges with standard guardrails must be provided.
- An open excavation or trench that is left open overnight must be barricaded, covered, and secured in a manner that prevents anyone from entering the excavation intentionally or accidentally.

5.2 Protective Systems

Sloping, shoring, or shielding will be provided in excavations, except where the excavation is made in stable rock or the excavation is less than 5 feet (1.52 m) deep and an examination by a competent person does not indicate a potential for cave-in.

5.3 Sloping

When sloping or benching is chosen as the method to protect employees in an excavation, one of the following optional designs of sloping and benching systems must be used:

- Option 1 – Slope the excavation at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal).
- Option 2 – Perform a soil classification and determine the acceptable slopes required.
- Option 3 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and must include the name and registration number of the engineer, detailed plans, the calculations used in the design, the magnitude of slopes, and the configurations determined to be safe. A copy of the design will be maintained at the jobsite during the use of the engineered system.

5.4 Shoring or Shielding

Only the following methods for support systems, shield systems, and other protective systems can be used at a TRC jobsite:

- Option 1 – Perform a soil classification and determine the appropriate support, shield or other protective system configuration using the shoring manufacturer's tabulated data.

When using the manufacturer's tabulated data, the shoring system must be installed in accordance with all the specifications, recommendations, limitations, or approvals to deviate issued by the manufacturer. The manufacturer's tabulated data, specifications, recommendations, limitations, and any approval to deviate must be in writing, and maintained at the jobsite during the use of the shoring system.

- Option 2 – Use a project-specific design prepared by a registered professional engineer.

  Engineered designs must be in writing, be rubber stamped, and include the name and registration number of the engineer, detailed plans, the calculations used in the design, and the sizes, types, and configurations of materials to be used in the support system. A copy of the design must be maintained at the jobsite during the use of the engineered system.

5.5 General Guidelines

The materials and equipment used for protective systems must be free of damage or defects that might impair their proper functions. Manufactured materials and equipment must be used and maintained in accordance with the recommendations of the manufacturer. If material or equipment used in a protective system is damaged, it must be inspected by a competent person before being reused.

The installation and removal of protective systems must be performed in accordance with all of the following guidelines:

- Members of support systems must be securely fastened together to prevent sliding, falling, kick-outs, or other predictable failures.
- Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or being struck by members of the support system.
- Individual members of support systems must not exceed their design capacities.
- Before individual members can be removed, additional precautions must be taken to protect employees, including installing other structural members to support any additional load imposed on the support system.
- Removal begins at, and progresses from, the bottom of the excavation. Members must be released slowly to reduce the likelihood of failure of the remaining members or a cave-in.
- Backfilling must progress with the removal of support systems.
- Support systems must be coordinated with the excavation of trenches and must extend to within 2 feet (0.61 m) of the bottom of the trench, but only if the system is designed to resist the forces calculated for the full depth of trench, and there is no indication of a loss of soil from behind or below the bottom of the support system.

- Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.
- Shield systems must not be subjected to loads exceeding their design capacities. Shields must be installed in a manner that restricts lateral or hazardous movement in the event that a lateral load is applied suddenly. Employees must be protected when entering or exiting the areas protected by a shield. Employees are not allowed within the shield during installation, removal, or vertical movement.
- When shield systems are used in trenches, excavation of material may proceed 2 feet (0.61 m) below the bottom of the shield only if the shield is designed to resist the forces calculated for the full depth of trench and there is no indication of a loss of soil from behind or below the bottom of the shield.

5.6 Soil Classification

This section describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits.

- Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C, in accordance with the definitions set forth in this compliance program.
- Soil and rock deposits are classified based on the results of at least one visual and one manual analysis. These analyses must be conducted by a competent person using the tests described in this chapter or other approved methods of soil classification, such as those adopted by the American Society for Testing Materials (ASTM) or the United States Department of Agriculture (USDA).
- The methods used for visual and manual analyses must provide quantitative and qualitative information sufficient to identify the properties, factors, and conditions of the deposits.
- A layered system must be classified based on the weakest layer. However, each layer may be classified individually when a more stable layer lies below a less stable layer.
- If, after classifying a deposit, the properties, factors, or conditions change in any way, the changes must be evaluated by a competent person. The deposit must be reclassified as necessary to reflect the new circumstances.

5.7 Visual Analysis

The visual analysis is conducted to collect qualitative information about the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the excavation, and soil samples taken from the excavated material. The visual analysis includes:

- Observing samples of the soil that are excavated and soil in the sides of the excavation to estimate the range of particle sizes and the relative amounts of particle sizes. Fine-grained material is cohesive.
- Observing the soil as it is excavated to determine if it stays in clumps. Soil that breaks up easily and does not stay in clumps is granular.
- Observing sides of the opened excavation and the surface area adjacent to the excavation to identify tension cracks or fissured material.
- Observing the area adjacent to the excavation and the excavation itself to identify existing underground utilities, structures, or previously disturbed soils.
- Observing the opened sides of the excavation to identify layered systems. Examine layered systems to determine if the layers slope toward the excavation, and to estimate the degree of slope in the layers.
- Observing the area adjacent to the excavation and the areas within the excavation to identify potential sources of vibration that might affect the stability of the excavation.
- Observing the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the water table.

5.8 Manual Analysis

Manual analysis is conducted to collect quantitative and qualitative information about the properties of the soil, and to provide more information to properly classify the soil. The manual analysis includes some or all of the following methods:

- Evaluating the plasticity of the soil by molding a moist or wet sample of soil into a ball and attempting to roll it into threads as thin as 1/8 inch (0.32 cm) in diameter. Cohesive material can be rolled into a thread at least 2 inches (5.08 cm) long without crumbling or breaking.
- Evaluating the cohesiveness of the soil. If the soil is dry and crumbles into individual grains or fine powder with little or moderate pressure, it is granular. If the soil is dry and falls into clumps that break into smaller clumps but the smaller clumps can only be broken up with difficulty, it might be clay in combination with gravel, sand, or silt. If the dry soil breaks into small clumps that can only be broken with difficulty and there is no visual indication the soil is fissured, the soil may be considered unfissured.

- Applying the thumb penetration test to estimate the unconfined compressive strength of cohesive soils. Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb and can be molded by light finger pressure.
- The thumb test should be conducted on an undisturbed soil sample, such as a large clump of soil, as soon as possible after excavation to minimize the effects of drying. If the excavation is later exposed to rain, flooding, or other moisture, the classification of the soil must be changed accordingly.
- Estimating the unconfined compressive strength of soils by using a pocket penetrometer or a hand-operated shear vane in accordance with the manufacturer’s recommendations.
- Performing a drying test to differentiate among cohesive material with fissures, unfissured cohesive material, and granular material. After thoroughly drying a sample of soil that is approximately 1 inch (2.54 cm) thick and 6 inches (15.24 cm) in diameter, evaluate the results as follows:
    - If the sample develops cracks as it dries, significant fissures are indicated.
    - If the sample dries without cracking and can be broken by hand, then the material is either unfissured cohesive or fissured cohesive.
    - If considerable force is necessary to break the sample, the soil has significant cohesive material content. The soil can be classified as unfissured cohesive material, and the unconfined compressive strength should be determined.
    - If the sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

5.9 Sloping and Benching Specifications

This section contains the specifications for using sloping and benching to protect employees working in excavations.

- These slope and bench specifications only apply if a soil classification has been conducted and the excavation will be 20 feet (6.10 m) deep or less.
- Determine the maximum allowable slope and configuration based on the soil classification by using the information in table(s) 1, 2 and 3.

Table 1 Maximum Allowable Slope Based on Soil Classification

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)(1) FOR EXCAVATIONS LESS THAN 20 FEET DEEP(3)
STABLE ROCK	VERTICAL (90º)
TYPE A(2)	3/4:1 (53º)
TYPE B	1:1 (45º)
TYPE C	1½:1 (34º)

1. The numbers shown in parentheses next to the maximum allowable slopes are angles expressed in degrees from the horizontal. The angles have been rounded off.
2. A short-term, maximum slope of 1/2:1 (63 degrees) is allowable in excavations in Type A soil less than 12 feet (3.66 m) deep. The short-term maximum allowable slopes for excavations deeper than 12 feet (3.66 m) is 3/4 (53 degrees).
3. Sloping or benching for excavations deeper than 20 feet (6.10 m) must be designed by a registered professional engineer.

Table 2 Excavations in Type A, B, and C Soils

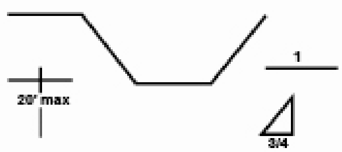
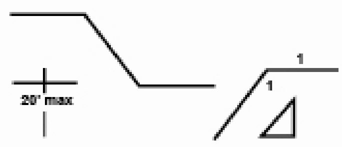
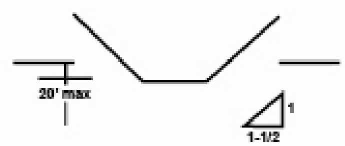
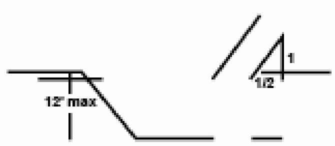
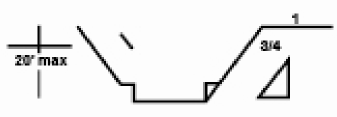
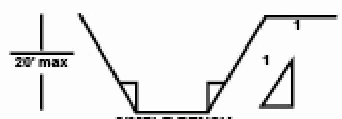
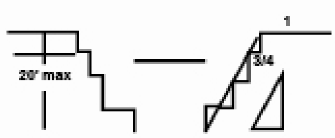
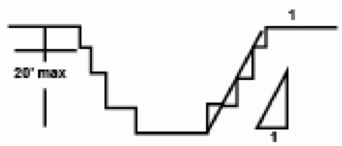
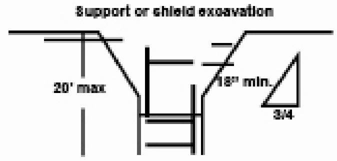
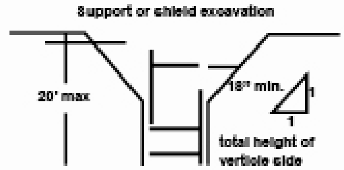
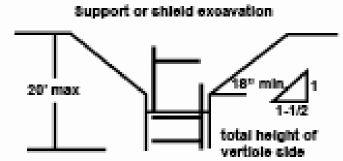
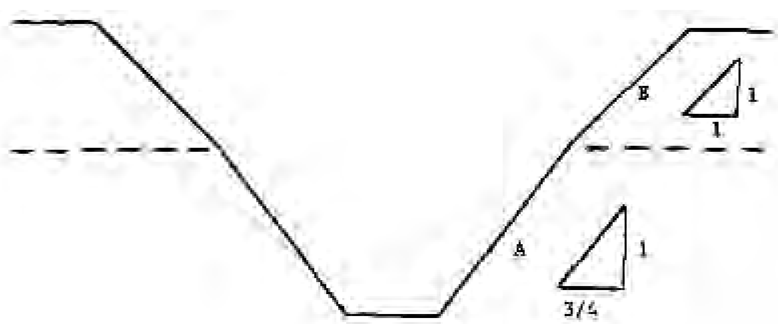
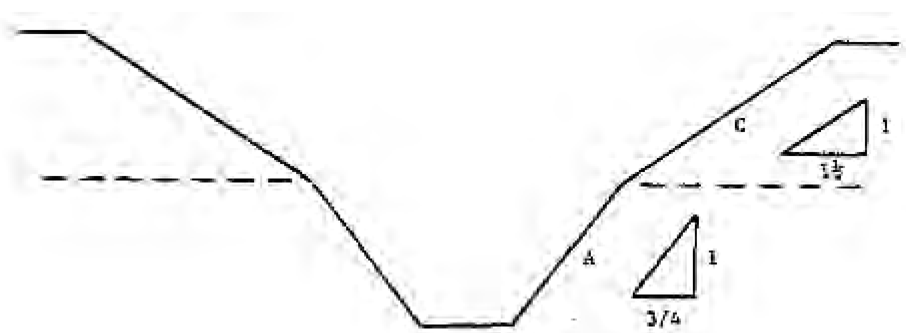
EXCAVATIONS IN TYPE A SOIL	EXCAVATIONS IN TYPE B SOIL	EXCAVATIONS IN TYPE C SOIL
SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE SLOPE	SIMPLE SLOPES LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1  SIMPLE SLOPE
EXCEPTION: SHORT-TERM SIMPLE SLOPES LESS THAN 12 FEET DEEP HAVE A MAXIMUM SLOPE OF 1/2:1  SIMPLE SLOPE SHORT-TERM		
BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1  SIMPLE BENCH	BENCHED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1  SIMPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
 MULTIPLE BENCH	 MULTIPLE BENCH	BENCHED EXCAVATIONS ARE NOT ALLOWED
SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 3/4:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1:1. Support or shield excavation  SUPPORTED LOWER PORTION	SUPPORTED OR SHIELDED EXCAVATIONS LESS THAN 20 FEET DEEP WILL HAVE A MAXIMUM SLOPE OF 1-1/2:1. Support or shield excavation  SUPPORTED LOWER PORTION
THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.	THE SUPPORT OR SHIELD MUST EXTEND AT LEAST 18 INCHES ABOVE THE VERTICAL SIDE.

Table 3 Excavations Made in Layered Soils

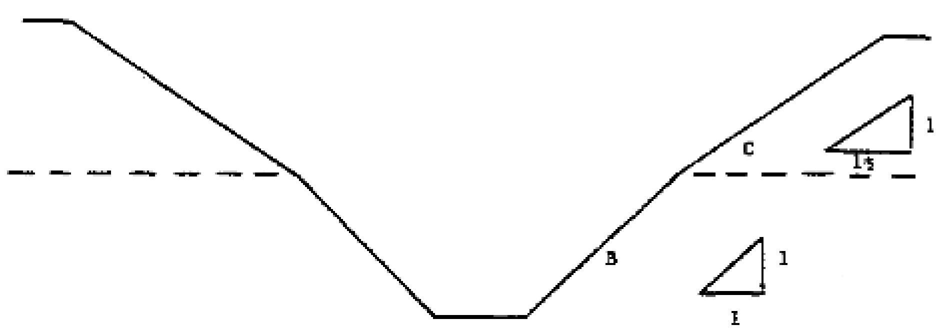
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



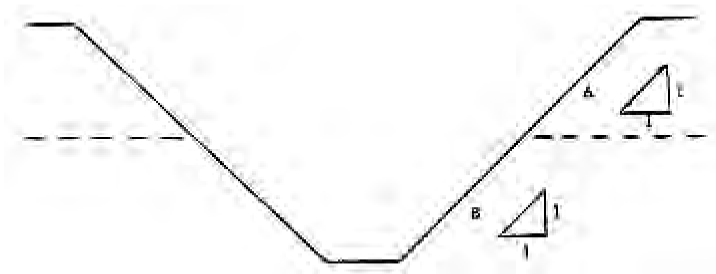
B OVER A



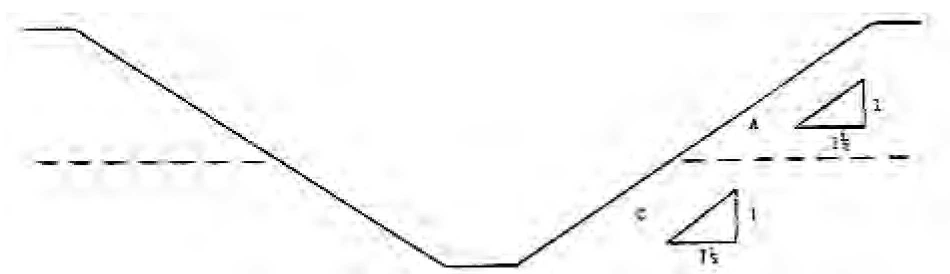
C OVER A



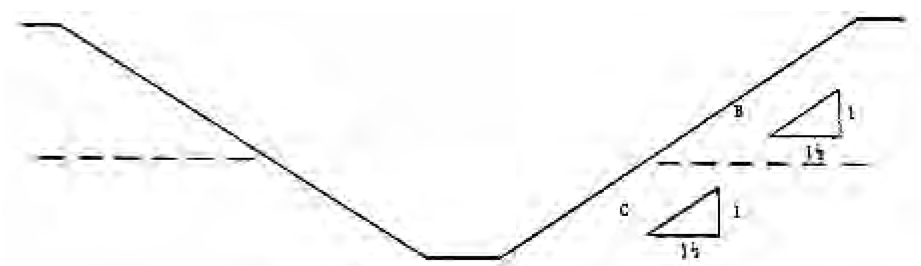
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

6. REFERENCES / RELATED DOCUMENTS:

29 CFR 1926 Subpart P, Excavations

CP002 – Risk Analysis Site Specific Health and Safety Program

CP003 – Personal Protective Equipment Program

CP008 – Confined Space Entry Program

CP009 – Health and Safety Training Program

7. APPENDICES

Forms

A. TRC Site-Specific Excavation Plan
B. TRC Pre-Excavation Checklist
C. TRC Excavation Inspection Form
D. TRC Protective Systems Selection Flow Chart

FORMS

A. **TRC SITE-SPECIFIC EXCAVATION PLAN**
B. **TRC PRE-EXCAVATION CHECKLIST**
C. **TRC EXCAVATION INSPECTION FORM**
D. **TRC PROTECTIVE SYSTEMS SELECTION FLOW CHART**

Site Specific Excavation Plan

Project Name: **Project #:**

Location: **Date:**

Company:

Submitted By:

Surface Encumbrances

Have Surface encumbrances that may create a hazard been removed or supported?

☐ Yes

☐ N/A

Underground Installations

Have Utility companies or owners been contacted? ☐ Yes ☐ N/A

By whom: Work Order #: Date:

When excavation operations approach the estimated location of underground installations, how will the exact location of the installations shall be determined?

☐ Probing ☐ Hand digging ☐ Detecting equipment ☐ Other

How will underground installations be protected?

☐ Support ☐ Removal ☐ Other

Access and Egress

Will structural ramps be used? ☐ Yes ☐ N/A

Designed by a competent person? ☐ Yes ☐ N/A

Will excavations be 4 feet in depth or more? ☐ Yes ☐ N/A

Means of egress (requiring no more than 25 feet of lateral travel) ☐ Yes ☐ N/A

☐ Stairway(s) ☐ Ramp(s) ☐ Ladder(s) ☐ Other

Exposure to vehicular Traffic? ☐ Yes ☐ N/A (If yes workers shall wear warning vests or other suitable garments.)

Exposure to falling loads? ☐ Yes ☐ N/A

☐ No workers permitted underneath loads

☐ Workers shall be required to stand away from any vehicle being loaded or unloaded. (Operators may remain in cabs)

Warning System for Mobile Equipment

Will mobile equipment operated adjacent to, or approaching the edge of, excavations have a clear and direct view of the edge of the excavation?

☐ Yes ☐ N/A If yes what warning system will be utilized?

☐ Barricade(s) ☐ Hand Signals ☐ Stop logs ☐ Other

Hazardous Atmospheres

Can oxygen deficiency or a hazardous atmosphere reasonably be expected to exist? ☐ Yes ☐ N/A

If yes, how will atmospheres in excavations greater than 4 feet in depth be tested?

If atmospheres contain less than 19.5% oxygen or other hazardous substance how will it be remediated?

When controls are intended to reduce the level of contaminants to acceptable levels, testing shall be conducted:

☐ Continuously ☐ Periodically

Will emergency rescue equipment be utilized? ☐ Yes ☐ N/A If yes what type?

☐ SCBA ☐ Harness and line ☐ Basket stretcher ☐ Other

Site Specific Excavation Plan

Water Accumulation

Will workers work in excavations in which there is accumulated water? ☐ Yes ☐ N/A

If yes is water controlled or prevented from accumulating by water removal equipment? ☐ Yes ☐ N/A

Equipment type: Competent Person:

Does excavation work interrupt the natural drainage of surface water (such as streams)? ☐ Yes ☐ N/A

Method used to divert water:

Stability of Adjacent Structures

Will the stability of adjacent structures be endangered by excavation operations? ☐ Yes ☐ N/A

If yes, what type of support structure will be used?

☐ Shoring ☐ Bracing ☐ Underpinning ☐ Other

If yes, but support structures will not be used, one of the following must apply:

☐ The excavation is in stable rock

☐ A registered professional engineer has determined that such work will not pose a hazard.

Name of registered professional engineer:

Protection from Loose Rock or Soil

How will workers be protected from materials or equipment that could fall or roll into excavations?

☐ Material placed > 2 feet from edge Retaining devices

Inspections

☐ Inspections of all excavations, adjacent areas and protective systems shall be made by a competent person.

☐ Inspections shall be conducted by the competent person daily, prior to the start of work and as needed throughout the shift. Inspections shall be documented on a Daily Excavation Inspection Form.

☐ Inspections shall be made after every rainfall or other hazard increasing occurrence.

☐ Where the competent person finds evidence of hazardous conditions, workers shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

Fall Protection

Will excavations be 6 feet or greater in depth? ☐ Yes ☐ N/A

If yes, fall protection will consist of:

☐ Barricades ☐ Fall restraint ☐ Harness ☐ Other

Will workers be required or permitted to cross over excavations? ☐ Yes ☐ N/A

If yes, guardrails shall be provided.

SIGNATURES

Supervisor	General Supervisor
Project/Construction Manager	Safety Representative

Pre-Excavation Checklist

Project Name: **Project #:**
Location: **Date:**
Company: **One Call #**
Submitted By:

The following procedures are mandatory. Failure to complete this check list could result in disciplinary action or termination:

Complete a pre-excavation walk-out of the entire job site. Your objective is to visually inspect the dig area to ensure all utilities are marked. Look for obvious signs of utilities in the immediate work area that may not be marked such as, above-ground pedestals, gas meters, man-hole covers, drains, or utility poles with cable risers. If you find these indicators and suspect that there is an unmarked utility DO NOT PROCEED**. Call your General Foreman or Locate Ticket Coordinator immediately.**

When you have completed your walk-out, complete the following check list:

1. Verify that the One-Call ticket covers the 'Scope of work' and 'Work to begin' date:

   I have verified the One-Call ticket covers the 'Scope of work' &'Work to begin' date ☐

2. What marked utilities did you observe?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

3. Based on visual observation, did you see any obvious signs of unmarked utilities in the immediate work area?

   ☐Yes ☐No If Yes, please identify?

   ☐Gas (Yellow) ☐Electric (Red) ☐Telephone (Orange) ☐Cable TV (Orange) ☐Water (Blue) ☐Sewer (Green)

4. I have notified my Supervisor and Locate Ticket Coordinator ☐

5. Photograph the entire proposed work area including all locate marks.

   I have photographed the entire site including existing locate/markings prior to excavation ☐

6. Advise your crew members of the following: If they have to cross a marked Utility they must HAND DIG ONLY within 18" of the locate marks. For gas lines add half the diameter of the buried facility to the 18''. If necessary, dig a test-hole (pothole) using hand tools to determine the location of the facility.

   I have advised my crew of this rule ☐

7. When possible, all directional boring / drilling routes must be potholed every 50-80 feet prior to drilling.

   I have advised my crew accordingly and test-holes (potholes) have been dug ☐

~~~~~~~~~~~~~~~~~~~~~~~~~~~ RESPECT THE MARKS! ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

IN THE EVENT OF DAMAGE

- Notify your Supervisor and Locate Ticket Coordinator
- Complete the TRC Incident Notification Form
- Photograph entire area and damage location

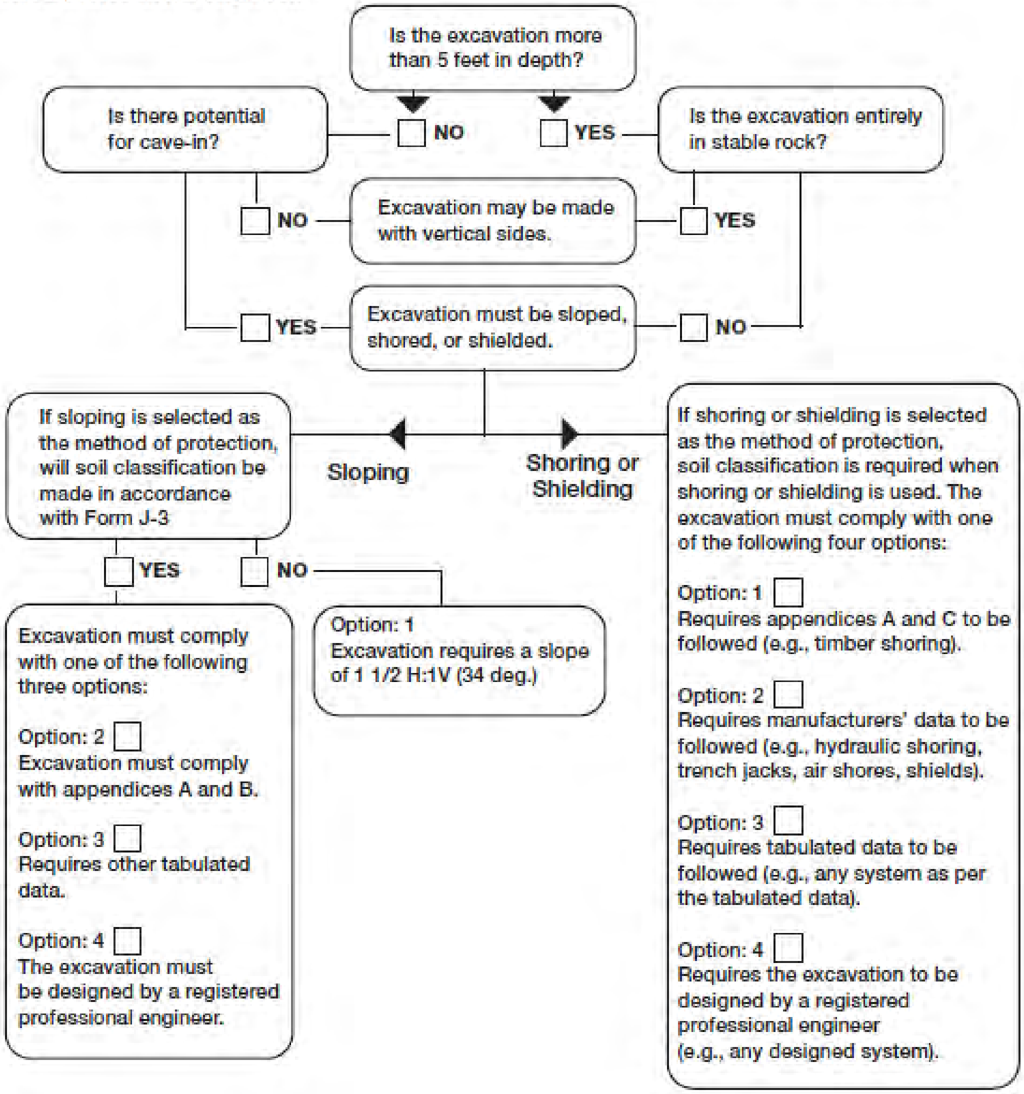
PHOTOGRAPHY TIPS

- Make sure the correct date & time stamp is active on your camera
- Photograph the excavation itself (damage location) and cable depth (include tape measure in hole)
- Take photos from multiple vantage points and of surrounding area (360 degrees)
- If the utility was miss-marked, photograph the locate marks/flags (include tape measure in photo)
- If the utility was not marked, photograph the entire area and approaches to the cut site
- Show a quantifiable location/address (street sign, house number, mail box number etc.)
~~~~~~~~~~~~~~~~~~~~~~~~~~~

Excavation Flow Diagram

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

The following is a graphic summary of the requirements for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer.



Excavation Daily Inspection

Project Name: **Project #:**
Location: **Date:**
Company:
Submitted By:

Depth: ________________________ **Width:** ________________________ **Date Opened:** ________________________

Soil classification: ☐ A ☐ B ☐ C

Indicate how the classification was made:

Manual test(s)

a) plasticity	________	________	________
b) dry strength	________	________	________
c) thumb penetration	________	________	________
d) pocket penetrometer	________	________	________
e) other	________	________	________

Visual test(s) **Do as many as possible**	**Cohesive Soil**	**Granular Soil**
a) Spoil pile	☐ **Remains in clumps**	☐ **Breaks up easily**
b) Trench Side	☐ **Stands vertical >2 hours**	☐ **Sloughs into trench**

The excavation is properly (circle one):

Shored/Shielded	**(indicate type of shoring)**	☐ **closed**	☐ **open**	☐ **wood**	☐ **metal**	☐ **shield**
Sloped/benched	**(indicate the slope)**	☐ **vertical sides**	☐ **3/4:1**	☐ **1:1**	☐ **1 1/2: 1**	☐ **2:1**

Excavation Checklist:	Morning	Mid-Day	Afternoon
Time:	________	________	________
Weather:	________	________	________
Was atmospheric testing required?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Was atmospheric testing done?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is the spoil pile back 2' from the edge?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Have surface encumbrances been removed?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Are there any signs of sloughing or cave-in?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is there water accumulation in the bottom?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Are there vibration sources near the excavation?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Is there adequate access/egress (ladder, ramp, etc.)	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Has the soil been disturbed previously?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Sides	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
Top	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**
If the excavation is > 20 feet deep, have engineering designs been documented and complied with?	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**	☐ **yes** ☐ **no**

SIGNATURES

Supervisor	General Supervisor
Project/Construction Manager	Safety Representative

Appendix D
Heat and Cold Stress

COLD STRESS

Ambient air temperatures during site activities may create cold stress for on-site workers. Procedures for recognizing and avoiding cold stress must be followed. Cold stress can range from frostbite to hypothermia. The signs and symptoms of cold stress are listed below.

Frostbite is defined as the actual freezing of one or more layers of skin. In severe cases, organs and structures below the skin can become frozen. Usually, body areas exposed to the most cold, and least body warmth, are affected first. These areas include fingers, toes, ears, and the tip of your nose. Frostbite is characterized by pain and loss of dexterity in the affected limb. The tissue initially appears reddened, but may progress to white, blue, or black.

> **FIRST AID:** Bring the affected employee indoors and call the local emergency clinic. Rewarming of frostbitten parts is best left to a medical doctor in a controlled setting.

Hypothermia is the condition that occurs when the body's natural warming mechanisms (muscle activity and shivering) cannot counteract the loss of body heat to the environment. The onset of hypothermia is greatly hastened by being wet. Hypothermia is marked by severe, uncontrollable shivering. The patient will show signs of excessive fatigue, drowsiness, irritability, or euphoria. As hypothermia progresses, the patient will begin to lose consciousness, blood pressure will drop, shivering will cease, and the patient may slip into a coma and possibly die.

> **FIRST AID:** If these symptoms occur, remove the patient to a warm, dry place. If clothing is wet, remove and replace with dry clothing. Keep the patient warm, but not overheated. The patient should be gradually rewarmed to prevent shock. If the patient is conscious and alert, warm liquids should be provided. Coffee and other caffeinated liquids should be avoided because of diuretic and circulatory effects. Notify the emergency clinic if conditions worsen, the patient loses consciousness, or the patient has an altered mental status. Have the patient transported to an emergency facility.

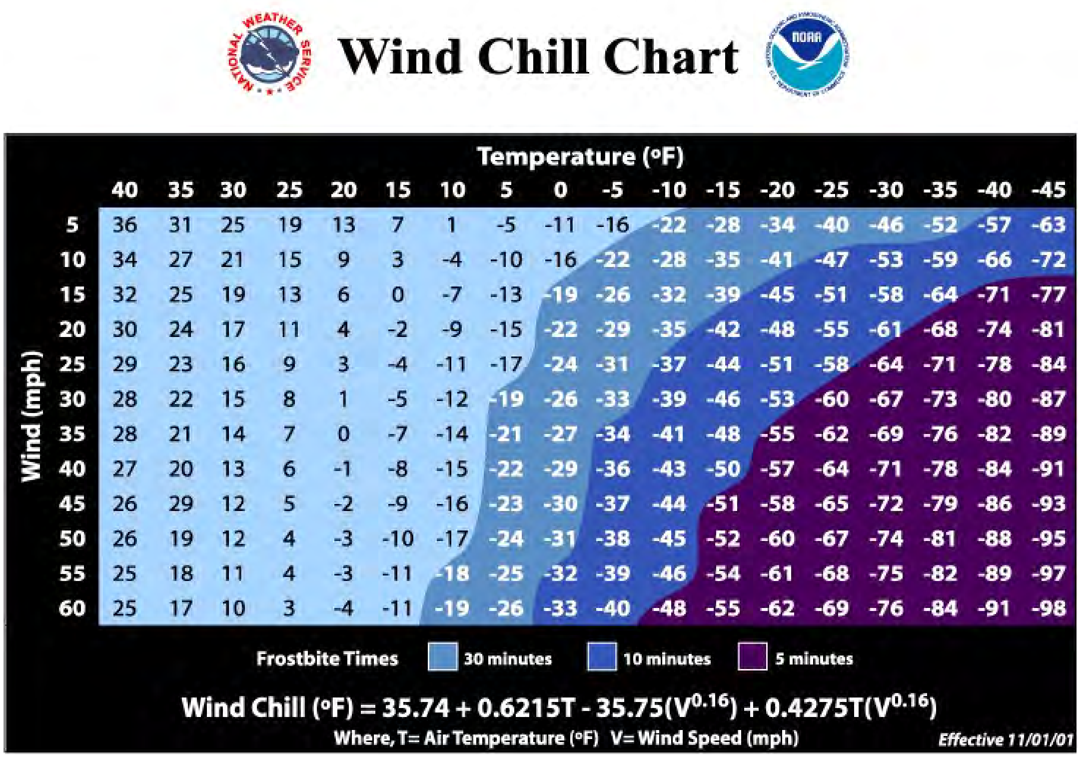
General Precautions The reduction of adverse health effects from cold exposure can be achieved by adopting the following work practices.

- Provide adequate insulating clothing to maintain core temperature at 98.6° F if work is to be performed in air temperatures below 40° F. Wind chill cooling rates and the cooling power of air are critical factors. The higher the wind speed and the lower the air temperature in the work area, the greater the insulation value of the protective clothing should be.
- If the air temperature is 32° F or less, hands should be protected by mittens/gloves.
- If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of clothing should be impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outer layer should be changed as it becomes wet. The outer garments should include provisions for easy ventilation in order to prevent wetting of the inner layer by sweat.
- If available clothing does not give adequate protection to prevent cold injury, work should be modified or suspended until adequate clothing is available, or until weather conditions improve.
- For prolonged work, heated shelters should be available. Workers should be encouraged to use these at regular intervals, with the frequency depending on the severity of the environmental exposure. When entering the shelter, the outer layer of clothing should be removed and the remainder of the clothing

loosened to permit heat evaporation, or a change of work clothing should be provided.

- Warm, sweet drinks, such as hot cocoa or soup, should be available at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of diuretic and circulatory effects.
- The weight and bulk of cold-weather gear should be included in estimating the required work performance and weights to be lifted in the field.

Workers should be instructed in safety and health procedures regarding cold work environments as part of the pre-work safety meeting. The training program should include instruction in preventing, recognizing, and treating cold stress conditions.



Wind Chill Chart

Wind (mph)	Temperature (°F)																	
	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

HEAT STRESS

There is a potential for heat stress from the use of protective clothing and climate conditions. One or more of the following procedures may be employed to alleviate potential heat stress problems in the event that site conditions warrant the use of personal protective equipment (PPE), or ambient temperatures exceed 85° F. Heat stress training must be emphasized during the daily safety meetings, and adequate supplies of potable water must be provided to workers each day.

General Precautions Provide plenty of liquids. To replace body fluids (water and electrolytes) lost because of sweating, use a 0.1 percent saltwater solution, more heavily salted foods, or commercial drink mixes. The commercial mixes may be preferable for those employees on a low sodium diet. Employees on low sodium diets, or other special diets, are advised to contact their personal physician for recommendations regarding appropriate electrolyte replacement fluids/beverages.

In extremely hot weather, conduct operations in early morning or evening and rotate shifts of workers wearing impervious clothing. Install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

Ensure that adequate shelter is available for breaks to protect personnel against heat, which can decrease physical efficiency and increase the probability of accidents.

Acclimatization for workers not accustomed to working in elevated temperature environments will be considered and implemented as appropriate in accordance with American Conference of Governmental and Industrial Hygienists (ACGIH) Guidelines.

Heat Stress Monitoring

For monitoring the body's recuperative ability toward excess heat, one or more of the following techniques should be used as a screening mechanism. Monitoring of personnel wearing impervious clothing should commence when the ambient temperature is 70° F or above. Frequency of monitoring should increase as the ambient temperature increases or as slow recovery rates are indicated. When temperatures exceed 80° F, regardless of the use of Personal Protective Equipment (PPE), workers will be monitored for heat stress after every work period.

Good hygienic standards must be maintained by the employee to aid in the prevention of heat stress illnesses. At a minimum, frequent changes of clothing and daily showering should occur with clothing being allowed to dry during rest periods. Persons who notice skin problems should immediately inform their supervisor.

Heart rate (HR) should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 25 percent. The HR is then measured again, once each minute for 2 minutes (a total of three measurements), after the initial rest period measurement. The HR should decrease by ten beats per minute between each measurement (a total reduction of 20 beats). If the HR does not decrease, the work period should be reduced by an additional 25 percent.

Body temperature can be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99°F. If it is greater than 99°F, the next work period should be shortened by 25 percent. The OT should be measured again at the end of the rest period to make sure that it has dropped below 99° F.

Effects of Heat Street

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat loading, a number of physical reactions can occur. The severity of these reactions ranges from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to severe (fatal).

Heat-related illnesses include:

Heat rash (also known as prickly heat rash) is caused by continuous exposure to heat and humid air and aggravated by chafing clothes. Heat rash decreases the ability to tolerate heat as well as being a nuisance. Signs are not limited to, but may include, a red prickly rash.

FIRST AID: Employees exhibiting signs of heat rash will be directed to shower and change into clean, dry clothing.

Heat cramps are caused by profuse perspiration with inadequate fluid intake and electrolyte replacement (especially salts). Signs are muscle spasms and pain in the extremities and abdomen, and may occur several hours after work has stopped.

FIRST AID: Employees showing signs of heat cramps will be directed to lie in a cool, shady area, and drink cool fluids. If symptoms persist or worsen, the employee will be transported to an emergency facility.

Heat exhaustion is caused by increased stress on various organs to meet increased demands to cool the body. Signs are shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and lassitude.

FIRST AID: Employees with signs of heat exhaustion will be brought to a cool, shady location and given fluids. After recovering, the employee will be dismissed for the day. If employee is unconscious, or conditions persist, the employee will be transported to a hospital.

Heat stroke is the most severe form of heat stress. The body must be cooled immediately to prevent severe injury and/or death. Signs and symptoms are red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and/or coma.

FIRST AID: HEAT STROKE IS A MEDICAL EMERGENCY. Employees will be brought to a cool area, aggressively treated by removing constricting clothes and applying wet towels or ice packs, and transported without delay to an emergency facility.

Appendix E
Tailgate Meeting/Checklist

Daily Pre-Job Safety Briefing

Project Name: ______________________ Project Number: ______________

Work Location: ______________________ Date: ______________

Tasks Performed: ______________________ Time: __________ AM PM

Client Name: ______________________ Submitted By: ______________

Weather: ______________________

Refuge Area: ______________________

First Aid/CPR Persons: ______________________

Potential Hazards: ______________________

For Emergencies Dial 911 **For Non-Emergencies Dial WorkCare (888) 449-7787**

Personal Protective Equipment Required

	Yes	***No***	***Specify***
Clothing	☐	☐	__________
FR, reflective vest, chemical, other (specify)			
Eye/Face	☐	☐	__________
Safety glasses, goggles, face shield, other (specify)			
Respirator	☐	☐	__________
1/2 face, full face, other (specify)			
Foot Protection	☐	☐	__________
Safety toe, EH rated, rubber boots, other (specify)			
Hand Protection	☐	☐	__________
Kevlar, chemical, EH, other (specify)			
Head Protection	☐	☐	__________
hard hat, electrical hazard, other (specify)			
Fall Protection	☐	☐	__________
body harness, lifelines, barricades, other (specify)			
Hearing Protection	☐	☐	__________
Other: __________			

Procedures/Programs Required	***Yes***	***No***
Confined Space	☐	☐
Hot Work	☐	☐
Signs/Barricades	☐	☐
LOTO/Energy Control	☐	☐
Scaffolds/Aerial Lifts	☐	☐
__________	☐	☐
__________	☐	☐
__________	☐	☐
__________	☐	☐
Employee Certification/Training Required		
HAZWOPWER	☐	☐
Asbestos Awareness	☐	☐
Asbestos Inspector	☐	☐
XRF Trained	☐	☐
__________	☐	☐
__________	☐	☐
__________	☐	☐

Additional Considerations

Work Procedures: ☐ Dig Safe
☐ Working clearances ☐ __________
☐ __________

People: ☐ Worker fatigue ☐ Other site activities
☐ Public safety ☐ Pedestrian control ☐ Experience
☐ Traffic control ☐ Other utilities
☐ __________

Tools/Equipment: ☐ Eye wash ☐ First Aid Kit
☐ Inspection of tools/equipment
☐ Specialized tools/equipment
☐ Correct tool/equipment for the job
☐ __________

Special Precautions: ☐ Environmental
☐ Condition of structures ☐ Weather conditions
☐ Lighting conditions ☐ Terrain ☐ Water bodies
☐ Adjacent structures
☐ __________

If Conditions CHANGE…Stop Work, Review and Revise the Plan!!

Daily Pre-Job Safety Briefing

Hazards Associated with the Job

☐ Hazardous Chemicals	☐ Heavy Equipment	☐ Slip/Trip and Falls	☐ Work in Active Rail ROW	☐ Confined space
☐ Biological Waste	☐ Hostile Individual(s)	☐ Traffic Hazards	☐ Work in Active Substation	☐ Hot Work
☐ Asbestos	☐ Ladder	☐ Trenches Excavations	☐Animals/Insects	☐ Radioactive Materials
☐ Dust	☐ Lighting	☐ Utilities	☐Plants	☐ Boom/Scissor Lift
☐ Edges/Material Handling	☐ Manual Lifting	☐ Water/Boat Safety	☐ ____________	☐ ____________
☐ Electricity	☐ Pressurized Fluids/Gases	☐ Weather (hot/cold)	☐ ____________	☐ ____________

List all hazards associated with this task

Signature of Crew Members Present

Print Name	Sign Name

Barriers to eliminate/control above hazards?

Supervisor Signature:

Post Task Safety Analysis

Did any injuries or incidents occur today? If yes, explain.

☐ Yes ☐ No

Was the injury or incident reported the safety department?

☐ Yes ☐ No ☐ N/A

What problems did you have with today's work assignment?

What can we do tomorrow to improve performance?

Appendix F
WorkCare Program Information

FACT SHEET

EARLY INCIDENT INTERVENTION®

Immediate Access to Medical Advice for Work Related Incidents

(888) 449-7787

INTRODUCTION

WorkCare, Inc. (WorkCare) and TRC have partnered together to promote Incident Intervention®, a resource designed to support company safety goals/targets—while reducing runaway-costs associated with workplace injuries and illnesses.

PURPOSE

Early Incident Intervention provides TRC employees with **IMMEDIATE** telephonic access to WorkCare clinicians at the time of a presumed, non-emergency workplace injury or illness. Clinicians provide expert guidance on the evaluation of symptoms, appropriate first aid, and the need for additional medical evaluation or treatment.

When utilizing this service within the first hour of an incident, known as the "Golden Hour," licensed medical staff can guide the case so that medical evaluation and treatment are rendered appropriately.

"…helps the worker traverse the unpredictable terrain of work-related injuries and illness."

PRINCIPLES OF EARLY INCIDENT INTERVENTION

- Utilizes principles of the "Golden Hour."
- Provides workers immediate clinician support at the time of an incident.
- Focuses on providing the right care, at the right time in the proper setting.

BENEFITS FOR EMPLOYEES

- Instant access to a medically qualified professional for evaluation of symptoms and possible outcomes.
- Professional guidance on appropriate first aid measures and medications.
- Professional advice regarding the need for additional medical evaluation or treatment.

BENEFITS FOR TRC

- Point of contact for emergency and non-emergency medical clinicians.
- Triages the incident to determine risk and urgency, delivering interventions that are consistent with medical guidelines for the specified injury and illness.
- Maintains communication with clinicians to ensure accurate and timely reporting.

Appendix G
Safe Catch Form

Safe Catch Report

A "Safe Catch" is a potential hazard or incident that has not resulted in any personal injury. Unsafe working conditions, unsafe employee behaviors, improper use of equipment or use of malfunctioning equipment have the potential to cause work related injuries. It is everyone's responsibility to report and/or correct these potential incidents immediately. Please complete this form as a means to report these "Good Catch" situations and submit to your local OSC Representative and Mike Glenn, SVP/National Safety Director.

Complete ALL field entries:

Employee Name:		Date:	
Location:		Office:	
Project Number:		Practice:	

Conditions

Please check all appropriate conditions:

☐ Unsafe Act	☐ Unsafe Condition	☐ Unsafe Equipment	☐ Unsafe Use of Equipment

Description of Incident or Potential Hazard:

Task Performed at Time of Incident:

Causes (Primary and Contributing):

Corrective Action(s) Taken (remove the hazard, replace, repair, or retrain):

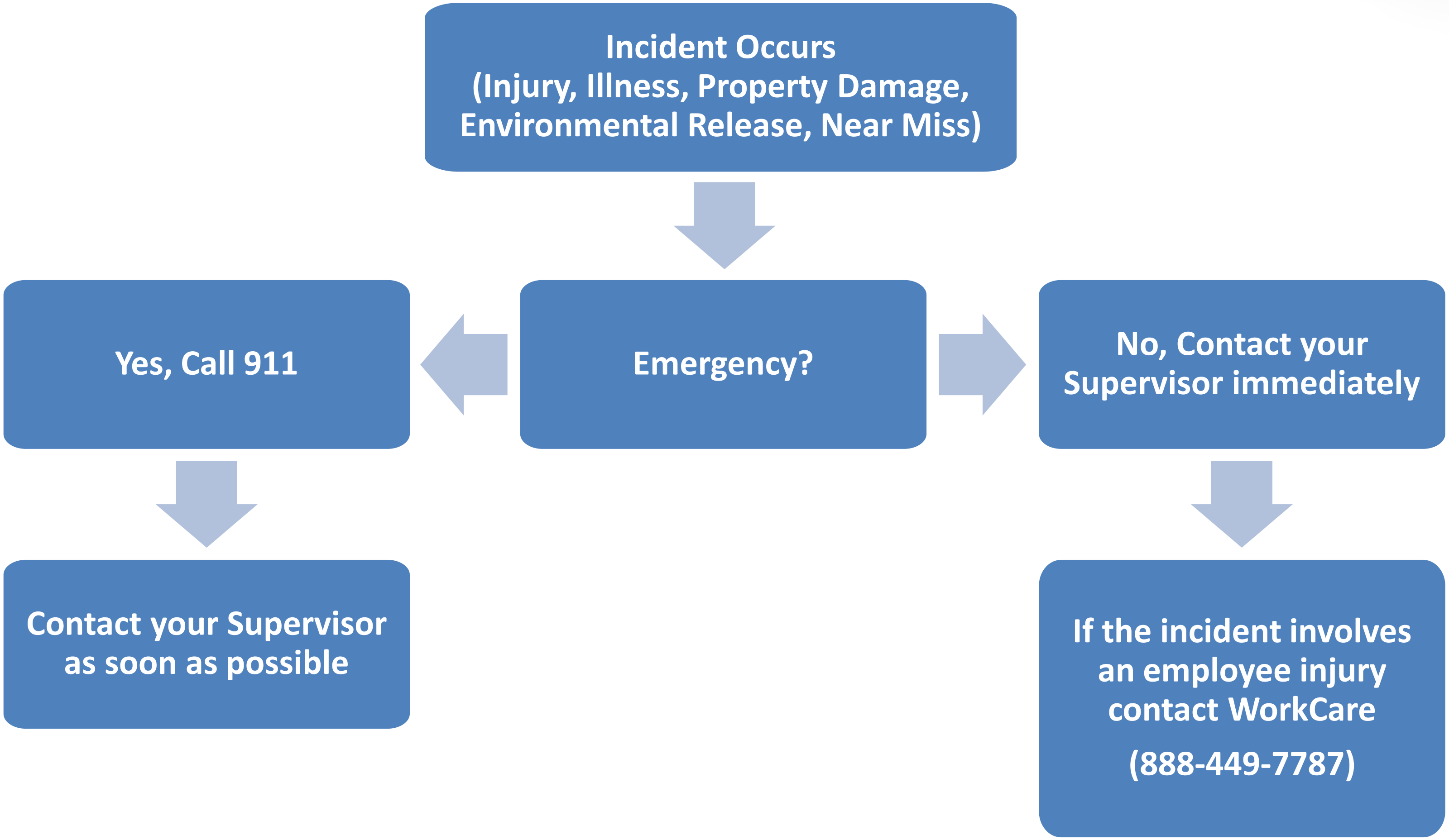
Employee Signature:		Date Completed:	

Our Mission: To reduce the frequency of incidents by applying local lessons learned globally.

If you have any questions about this report or would like additional information, please reference Compliance Program CP019 TRC Incident Response and Lessons Learned Program, located on TRCNET or contact Mike Glenn, SVP/National Safety Director at mglenn@trcsolutions.com.

Appendix H
In Case of Emergency and Incident Reporting

Incident Response Flow Chart - Employees



In Case of Injury at Work

1 If emergency care **is** needed, or if you are in a motor vehicle incident, call 9-1-1.

2 If emergency care **is not** needed, notify your supervisor **prior** to the initial contact with **WorkCare (888.449.7787).**

3 Supervisor must notify a Corporate Health and Safety Team Member.

Submit the appropriate form(s): TRC Incident Notification Report or TRC Auto Incident Report **within 24 hours** to Mike Glenn, VP, National Safety Director.

TRC
Results you can rely on

Appendix I
Job Safety Analysis Forms

Job Safety Analysis Template

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State) **TRC**		DATE PREPARED FOR HASP:	☐ NEW ☐ REVISED
JSA WORK ACTIVITY (Description):		List of Contractor(s) and key work activity:	
SITE SPECIFIC JSA AUTHOR	**POSITION / TITLE**	**DEPT**	**SIGNATURE**

TRC HEALTH AND SAFETY MANAGEMENT	**POSITION / TITLE**	**APPROVAL DATE**

PERSONAL PROTECTION EQUIPMENT (PPE) QUICK SUMMARY
Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

____ REFLECTIVE VEST ____HARD HAT _____GLOVES: **ANSI Cut Level** ____ **Kevlar** ____SAFETY GLASSES ______GOGGLES ______FACE SHIELD	_____ HEARING PROTECTION ____SAFETY SHOES: Protective Toe _____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ____Tyvek Suit ____Nomex ____Other (specify):	RESPIRATORY PROTECTION: ☐ NA ____½ face Air Purifying Respirator (APR) _____Particulate Mask: ☐ PM100 ☐ PM95 _____ Cartridge: ☐ P100-Multigas ☐ _______________ _____Full face ARP; specify cartridge type: _____ Air Supplied Respirator ____SCBA _____Air-line	Additional PPE: .

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1)	a.	
	b.	

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.		
[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
2)		
3)		

Always perform a Safety Assessment (Hazard Hunt): 1) prior to starting work; 2) when changing tasks; and 3) throughout the day.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
3)		
4)		
	LOCATION(S) WHERE HAZARD IS TO BE EXPECTED	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1.	a.	a.
2.	a.	a.
3.	a.	a.

Field Notes:

____

____

Appendix J
Acknowledgement

PERSONAL ACKNOWLEDGEMENT

A component of the HASP, designed to provide personnel safety during work activities described herein, requires that you receive training as described in the HASP prior to working at this site. Additionally, you are required to read and understand the HASP. When you have fulfilled these requirements, please sign and date this personal acknowledgement:

Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
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Name (Printed)	Signature	Date
Name (Printed)	Signature	Date

APPENDIX C
DOWNHOLE GEOPHYSICAL SURVEY PROCEDURES

GEOPHYSICS FOR THE ENGINEERING & ENVIRONMENTAL COMMUNIITIES

2 Industrial Way S/2, Atkinson, NH 03811 (603.893.9944)
846 Main Street, Fords, NJ 08863 (732.661.0555)

www.hager-richter.com

HAGER-RICHTER GEOSCIENCE, INC. (HRGS)
BOREHOLE GEOPHYSICAL LOGGING
EQUIPMENT INFORMATION & STANDARD OPERATING PROCEDURES

Hager-Richter Geoscience, Inc., dba HR Geological Services in New York, (HRGS) will conduct the specified borehole geophysical logging using the equipment and minimum standards outlined herein. HRGS has specialized in high resolution surface and borehole geophysical services for the engineering and environmental communities since 1984. In those 39 years, HRGS has earned a national reputation for excellence, and is now one of the largest geophysical specialty firms in the eastern United States.

HRGS has decades of experience providing the requested borehole geophysical logging services for NYCDEC investigations. HRGS is licensed to offer geological/geophysical services in the state of New York, and the project, will be directly supervised by an HRGS Principal licensed as a NY Professional Geologist (PG) in the state of NY. Such continuing commitment by a Principal is a major factor in producing the uniformly high-quality work that clients have come to expect from HRGS. Our rigorous QA/QC program includes review of all reports by a Geophysical Technical Review Team. HRGS is licensed to provide geological services in the state of New York and our highly trained field crews have in-depth experience in the specific geophysical techniques that we use.

Equipment

General

A Mount Sopris Matrix portable digital logging system will be used with a 4MXA-1000 or comparable winch for the borehole geophysical logging. Data are displayed and recorded in real time in the field on a laptop computer and are processed in the office.

Optical Televiewer

An ALT QL40-OBI-2G optical televiewer (OTV) probe will be used for the OTV logging. The OTV probe acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall. The image can be used to detect and determine the orientation of bedrock structures such as fractures, foliation, and bedding and to characterize bedrock conditions and changes in lithology. The probe includes deviation sensors (3-axis magnetometer and 3-axis accelerometer) to orient the televiewer image and to provide borehole deviation data that are used to correct bedrock structure orientations from apparent to true orientations and to provide the location of the boreholes with depth.

Acoustic Televiewer

An ALT ABI-40 or QL40-ABI-2G acoustic televiewer (ATV) probe will be used for the ATV logging. The ATV probe acquires a high resolution, effectively continuous, magnetically oriented, 360° image of the borehole wall using the reflected signal of sound waves in the ultrasonic frequency range. Both amplitude and travel time of the reflected signals are recorded and can be used to detect and determine the orientation of bedrock structures such as fractures, foliation, and bedding and to characterize bedrock conditions and changes in lithology. The probe includes deviation sensors (3-axis magnetometer and 3-axis accelerometer) to orient the televiewer image and to provide borehole deviation data that are used to correct bedrock structure orientations from apparent to true orientations and to provide the location of the boreholes with depth.

Acoustic Caliper

Acoustic caliper data provide the average borehole diameter as a function of depth. The acoustic caliper log is derived from the acoustic travel time data from the ATV probe and the velocity of the acoustic signal in water. The caliper log is used to determine the diameter of the borehole, detect open fractures and voids, and to aid in the interpretation of other borehole geophysical logs. The acoustic caliper data will be evaluated in the field, if the quality of the acoustic caliper data is not of sufficient quality, mechanical 3-arm caliper data will also be acquired. In general, acoustic caliper data is superior to 3-arm caliper data except in very large diameter boreholes or in conditions with soft and/or highly weathered bedrock.

Fluid Temperature

A Mount Sopris QL40-FTC or comparable fluid temperature and conductivity/resistivity probe or comparable will be used for the fluid temperature logging. The probe uses a semiconductor sensor for which the voltage output is linearly related to temperature. Temperature logs record the temperature of the borehole fluid with depth and are useful for detecting flow into or out of a borehole. If fluid temperature contrasts are present between the borehole fluid and fluid in hydraulically transmissive fractures/fracture zones, the fluid temperature logs can be useful indicators of flow into and out of a borehole.

Fluid Conductivity/Resistivity

A Mount Sopris QL40-FTC or comparable fluid temperature and conductivity/resistivity probe or comparable will be used for the fluid conductivity/resistivity logging. The probe uses an electrically shielded Wenner array to measure the capacity of the borehole fluid to transmit electric current with depth and can be an indicator of salinity and water quality. If fluid conductivity/resistivity contrasts are present between the borehole fluid and fluid in hydraulically transmissive fractures/fracture zones, the fluid conductivity/resistivity logs can be useful indicators of flow into and out of a borehole.

Resistivity is the physical property that relates electric current density to potential gradient and is defined as:

$$\rho = (A / L) * (V / I) \qquad \text{Eq. 1}$$

where:
- ρ is resistivity
- A is cross-sectional area of a homogeneous tube
- L is length of the tube
- V is potential
- I is current

Conductivity is the inverse of resistivity as defined above.

Heat Pulse Flow Meter

A Mount Sopris HFP-2293 or comparable heat pulse flow meter (HPFM) will be used for the HPFM logging. The HPFM measures the vertical rate and direction of fluid flow in a borehole at discrete depths and is designed to be used for boreholes with flow rates less than one gallon per minute (gpm). A heating grid heats a thin sheet of water in a short time interval (less than 0.05 seconds), and, if vertical flow is present, the sheet of water moves along the borehole in the vertical direction of flow. Temperature sensors located at known distances above and below the heating grid monitor the differential temperature of the borehole fluid. The time required for the sheet of heated water to reach one of the sensors is measured, and based on the probe calibrations, the time is used to calculate the vertical flow rate in gpm. Depths where water flows into and out of the boreholes can be interpreted based on changes in the vertical flow rate and/or direction. HPFM measurements will made under both ambient and stressed (low constant rate pumping) conditions.

Measurement depths are selected based on information provided by other borehole geophysical logging data such as OTV, ATV, fluid temperature, and fluid conductivity/resistivity. To make a measurement, the probe is positioned at a selected depth and the probe is stabilized by the friction between the centralizers and diverter petals on the probe and the borehole wall. When the borehole fluid has stabilized after the disturbances caused by the probe being moved to the measurement depth, the heating grid is fired, and a measurement cycle starts.

Borehole Geophysical Logging Data Acquisition Sequence & Parameters

	Borehole Geophysical Log	Sampling Interval	Logging Speed
1	Fluid Temperature & Fluid Conductivity/Resistivity*	0.10 feet	8-12 feet/minute
2	OTV*	0.01 feet	8-12 feet/minute
3	ATV & Acoustic Caliper*	0.01 feet	8-12 feet/minute
4	HPFM - Ambient Conditions	HPFM data will be acquired at discrete depths under ambient conditions.	
5	HPFM - Pumping Conditions	HPFM data will be acquired at discrete depths under low constant rate pumping conditions.	

* Repeat section are acquired for at least 20% of the open bedrock interval of each borehole.

Equipment QA/QC, Calibration, and Standardization

Depth Encoder

The depth encoder is calibrated by the equipment manufacturer and calibrations are regularly checked compared to a tape measure. In the field, adequate tension is maintained with the logging cable during the borehole geophysical logging and the depth encoder is cleaned regularly to maintain accurate depth measurements. Repeat sections are acquired to verify depth consistency. In addition, at the beginning and end of a logging run, a fiducial depth (top of casing or ground surface) is measured and checked for consistency. Recorded depths of fixed features in the borehole (i.e. reported casing lengths and reported borehole depths) are also checked for depth consistency.

Optical Televiewer & Acoustic Televiewer

The orientation sensors in the OTV and ATV probes are calibrated by the equipment manufacturer and are regularly checked for tilt and azimuth calibrations using a compass. To verify consistency of the televiewer images and orientations, data from the OTV and ATV, two independent probes, are compared to each other for consistency. In addition, repeat sections are also acquired in each borehole.

Acoustic Caliper

The borehole diameter measurements are calibrated regularly in PVC tubes of known diameter and the measurements are checked in the field in portions of the boreholes with known diameters such as in the surface casing.

Fluid Temperature & Fluid Conductivity/Resistivity

The fluid temperature and fluid conductivity/resistivity sensors are calibrated by the equipment manufacturer and calibrations are regularly checked and updated using independent temperature and conductivity sensors/probes. Performance tests are also conducted on the fluid temperature and conductivity/resistivity sensors in the field by observing changes in the data at the air-filled to water-filled interfaces in boreholes and repeat sections are also acquired for the full length of each borehole.

Heat Pulse Flow Meter

To verify consistency, multiple measurements are made at each sample depth. HPFM calibrations are regularly checked using a calibration flow tube. In addition, the borehole flow rates are checked in the field in portions of the borehole with known flow, such as in the casing when the water level is static or in the casing under known pumping conditions.

To ensure reliable HPFM measurements, the borehole water level is monitored and recorded throughout the HPFM testing in each borehole. To ensure consistent pump rates during HPFM data acquisition, pump rates are monitored continuously during the HPFM testing. In addition, HPFM measurements are not started until a stable pump rate is achieved and the borehole water level has stabilized or come to a low steady head change, both of which are documented in the field notes.

Sincerely,
HAGER-RICHTER GEOSCIENCE, INC.

Robert L. Garfield

Robert L. Garfield, P.G. (NY 000041)
Owner / Principal Borehole Geophysicist

APPENDIX D
FLUTE HYDROGEOLOGIC CHARACTERIZATION INFORMATION

Blank Liner Installation Procedure

FLUTe™ Flexible Liner Underground Technologies, LLC

835 Nina Way, Warminster, PA 18974

Installation Procedure
for
FLUTe Blank Liners

Prepared by:

Flexible Liner Underground Technologies
835 Nina Way
Warminster, PA 18974
215-394-5760

Last Revised:
4/18/2022

FLUTe

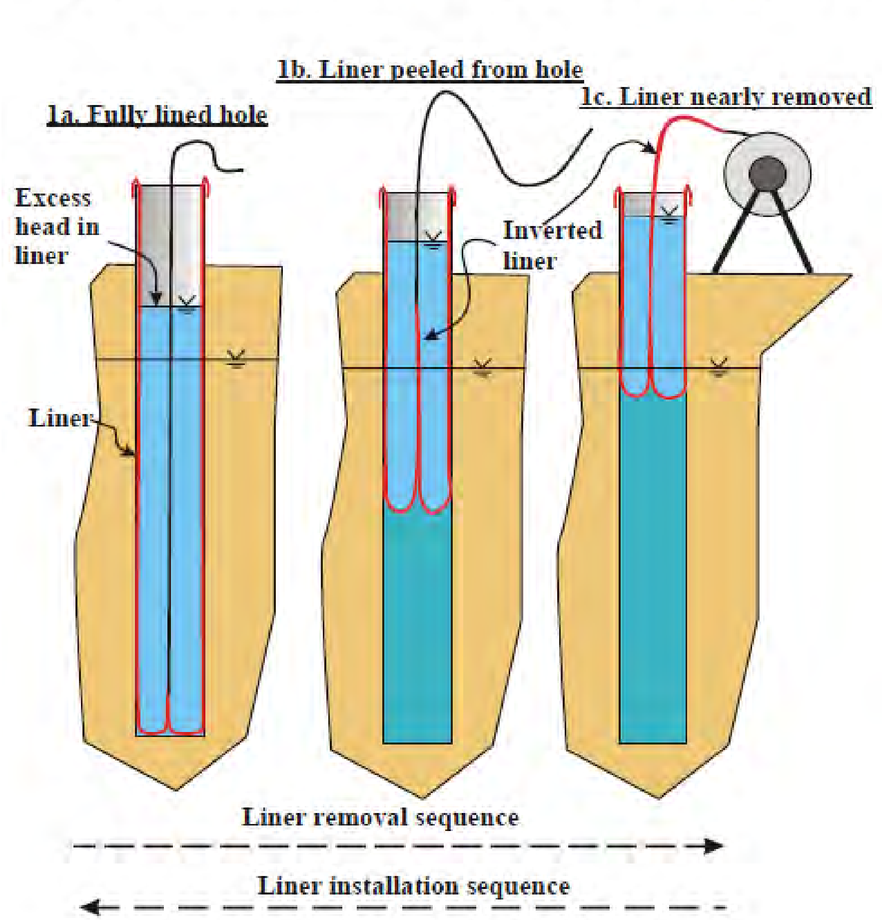
Table of Contents

The FLUTe® Blank liner

Method: The FLUTe blank liner is a tubular urethane coated nylon liner which is normally everted into place as shown in Fig. 1. It is easier to understand the everting process if one starts with the lined hole of Fig. 1a. The excess head inside the liner, above the water table in the formation, forces the liner out against the hole wall and forms a continuous seal of the hole much like a continuous packer. By pulling up on the tether shown in the figure, the liner inverts and can be peeled from the hole wall as the tether and then the liner are wound on a reel at the surface (Fig. 1b-1c).

The installation procedure for the blank liner is the reverse procedure (Fig. 1c-1a). Illustrated in Fig. 1c, the inside-out liner is pulled from the reel and clamped to the top of the casing. The liner is pushed down into the casing to form an annular pocket. Water is added to the interior of the liner forcing the liner against the hole wall and down the hole, pulling the liner from the reel. As the liner "everts" down the hole (the reverse of peeling it out of the hole), the water in the borehole is forced into the formation. The liner will continue to descend into the borehole until it reaches the bottom of the hole or until all flow paths in the borehole are sealed by the liner and the water beneath the liner cannot be forced into the formation, shown in Figure 1a.

Fig. 1. Blank liner removal and installation sequence



Uses: The blank liner is a convenient method for sealing the borehole to prevent contaminant transport in the hole. Many geophysical measurements can be performed inside the liner, with the liner sealing the hole. Those measurements are: gamma and gamma-gamma logs, induction coupled electric log (resistivity), sonic logs of several kinds, temperature logs, radar measurements, and neutron moisture logs in the vadose zone. A very attractive use of the blank liner is the measurement (i.e., location and flow rate) of all significant flow paths in the borehole while the liner is descending into position. For details on this *Hydraulic Conductivity Profiling Technique,* visit www.flut.com, or call us at 215-394-5760.

Equipment Needed

- Steel Reel Stands and Axle
- Poly Tubing, Trimmie Pipe (1/2”, ¾”)
- Band Clamp
- Tether Bar
- Water Source
- Venturi Vacuum Pump
- Compressed Air Source
- Green Machine (Optional)

Installation Procedure

1. Tag depth of hole and static water level.
2. Setup liner by sliding an axle through the liner reel and place it onto reel stands.
3. Remove plastic wrap, bubble wrap, and documentation from liner**. Do not use knives or sharp objects to open liner**. Keep documentation for notes.
4. Remove poly tubing from the reel, slightly scallop the bottom end of the poly (approximately 5-10 feet up from the bottom).
    a. For blank liner installations used to seal open boreholes, the poly tubing will act as a vent tube during liner eversion from ground surface to the water table. This vent tube will be a migration pathway for air to escape from the open borehole above the water table and will prevent a “balloon” from forming inside the liner during the initial installation.
    b. The vent tube should sit a couple inches above static water level. It is best to measure how far it is placed downhole by measuring it beforehand on the ground. To know that it’s sitting at or slightly above the water table, it may be useful to force air by blowing into the poly to hear bubbling. **Do not drop poly downhole; firmly secure it to the reel stand or casing.**
    c. The same poly tubing may also act as a pump tube when used for NAPL/FACT liner installations in which the liner needs to evert and seal the entire length of the borehole, whether the borehole is transmissive or not.
5. Place liner reel over top of the casing so that the liner aligns center over the casing.
6. Depending on if the liner will later be used for a transmissivity profiling test of the borehole, the length of extension on the liner may need to be left as is during the installation process.

a. If a profiling test is to be performed, the extension will be used to help create a higher head above static water level in order to have the appropriate driving pressure during the liner's eversion.
b. If the hole is not to be profiled, the extension on the liner may be trimmed to align the ground surface (G.S) mark on the liner with ground surface of the well.

For Vault Installations

7. If the casing is in a vault: measure down to the top of the casing from G.S and make note of the length.
8. Measure this same distance from the ground surface mark shown on the liner towards the direction of the reel and mark a line with a sharpie. This will allow the G.S mark on the liner to match ground surface, and the new marking will align with the top of casing.
9. **Do not cut on your original line.** Using scissors, cut straight across the liner at a place in between the G.S line and the new marking as this area will be used to secure the liner to the top of the casing (It is best to have a ~2" overlap). Do not cut the bubbler tube located within the yellow weld strip.
10. Cut a small (2") vertical slit down along the seam of the liner from the top. This slit will go around the vent tube when the liner is folded over the casing. It is best to match the seam of the liner with the same side of the vent tube, the vent tube may need to be moved to align correctly with the slit.
11. Cut a 0.5-1ft vertical slit down the thin yellow strip the covers the bubbler. Do not cut all the way through both sides of the yellow lining.
12. Pre-evert the liner to a length of 5-6 ft and lower into the casing. Pre-eversion is required as the liner needs to overcome the minimum pressure to initially displace downhole.
13. Align the new marking with the top of the casing, fold over, and clamp liner to the top of the casing using the provided band clamp. It may help to secure the liner first with electrical tape to make putting the band clamp on easier.

For Casing Stickup Installations

14. If the casing sticks up above ground surface measure the height from G.S to top of casing and make note of the length.
15. Measure this same distance from the ground surface mark on the liner towards the direction of the end of the liner away from the reel and mark a line with a sharpie. This will allow the G.S mark on the liner to match ground surface, and the new marking will align with the top of the stick up.

16. Using scissors, cut straight across the liner at a place 2-3" above the new marking as this area will be used to secure the liner to the top of the casing with enough overlap. Do not cut the bubbler tube located within the yellow weld strip.
17. Repeat steps 10 through 12.

Continued Blank Installation

18. Once the liner is pre-everted and clamped, place the water source into the top of the casing and begin filling the liner, keep the liner from moving downhole for the initial pre-eversion length and fill to top. This will give the liner enough head to evert down to the water table.
19. The water source may be shut off during the liner's eversion down to the water table. Too much initial head can cause the liner to evert at a fast rate and fly downhole to the water table. Allow enough tension on the liner to ease it down to the water table.
20. As the liner reaches the water table, there should be a noticeable change in liner back tension. At this point, fill the liner so you have roughly 10' above the static water level of the hole, and allow the liner to evert naturally. Keep the water level inside the liner at roughly 10' above the static water level of the hole for the entirety of the installation.
21. The rate at which the liner descends is based on the flow beneath the liner in the open borehole.
22. A venturi vacuum pump may be used to remove air from the inside of the inverted part of the liner so that a balloon does not form inside the liner itself. The venturi will attach to the clear vent tube that is spooled on the reel with the tether and will connect to an air hose.
23. As the liner descends, eversion point (E.P) markings will show at intervals on the liner, representing the depth at which the bottom of the liner is currently at.
24. At the halfway point there will be a knot attaching the liner to the tether, this is the bottom of the liner that will evert down to the bottom of the borehole. The tether will run the length of the entire borehole up to the surface. Disconnect the venturi as it will no longer be useful once the vent tube goes downhole.
25. As the liner slows with depth the tether line will be tied off to the tether bar to keep tension on the liner and to keep the system in place.
26. Once the liner stops or reaches a velocity of 20 inches a minute or less, tie an overhand knot in the tether line (shown below), place the tether bar through the knot, and rest on top of the casing. There should be little to no slack on the tether line once the liner is tied off.

27. Top off the water in the liner as it may continue to dilate over time. The water level in the liner will slowly drop until the liner is fully dilated.
28. The installation process is complete once the water level in the liner remains static. Note the amount of water used during installation.

NAPL Blank install in open hole

Installation procedure for NAPL blank liner in open borehole below the water table

(see note on last page for installation in the vadose zone)

This liner is a blank liner covered with a reactive covering. The liner is shipped inside-out with the cover on the inside of the liner. Care must be exercised to assure that the outer covering is not twisted with respect to the liner. This is especially true while the liner is inside-out on the reel.

1. Tag the hole depth to assure that it is known.
2. Tag the water level in the hole. Compare to the bubbler depth if a bubbler is included in the installation.
3. Smooth the top of the casing to assure that there are not very sharp edges that will threaten the liner.
4. Set the liner reel on an axle and supports to allow easy deployment of the liner. The liner is marked with an arrow. The arrow should point towards the well over the top of the reel. Unwrap the reel protective layer. Do not use any blades. A scissors without sharp edges is okay, but be careful to not cut the liner.
5. Insert the steel rod in the end of the vent tube. Tape the last 2 inches of the rod so that it is wedged firmly in the vent tube and will not fall out of the tube. Install the vent tube to the bottom of the hole. Tie the top end of the vent tube so that it is suspended about 4 inches off the bottom of the borehole.
6. Pull off about 10 ft. of liner and evert the liner back upon itself about 5 ft. as in the drawing. Evert the covering over the everted liner if the liner is not stapled to the cover. Be careful that the covering is not twisted relative to the liner. The cover may have been stapled to the liner to assure that it is not twisted.
7. Slide the everted liner down into the casing as shown.
8. Slit the open end of the liner/cover about 6 inches and fold about 3 inches of the liner and cover over the top edge of the casing. If the casing is large, make two slits on opposite sides. Tape the cover to the top of the casing. Put two clamps over the tape to hold the liner and cover securely to the casing. The vent tube can pass through the slit.

9. Set the wellhead roller over the casing. Drape the inverted liner over the wellhead roller to guide the liner into the hole. If a wellhead roller is not available and the reel axle is higher than the casing, the liner can be deployed directly from the reel.
10. Water can now be added to the interior of the liner. Lower the liner until about 10 ft deep in the casing. Fill the liner to the top of the casing, if the wt. is not too deep. For a 6 inch or larger diameter, 5 ft of water is sufficient.
11. Stop the water addition, and lower the liner slowly to the water table. See the footage marks for that distance (if footage marks are on the liner). The hanging wt. of the liner should decrease dramatically as the liner descends into the water.
12. Keeping about 5-10 lb. of tension on the liner (i.e., restrain the descent), continue to add water to the liner until it reaches the bottom of the hole. At about the half distance into the hole (i.e., the eversion point is at the half depth.), the liner will stop until the air has bled out of the end of the liner via the press. relief valve. Add another 10 gallons of water to submerge the air bubble to hasten the air vent. When the liner starts to move again, continue adding water until the liner reaches the bottom of the hole. *This venting of the air is only needed at the end of the liner*.
13. Be very careful to not let the tether go down the hole. Secure it to the tether bar supplied with the liner when the liner is all the way down the hole. If there is no tether because of the liner length, tape and tie the liner so that it does not continue down the hole. The liner should be sitting on the bottom of the hole.
14. Leave about 5-10 ft. of excess water head in the liner. More is not a concern. This will press the liner/cover firmly against the borehole wall.
15. Let the liner sit in the hole until the retrieval is to be done. This can be done after ~1/2-1 hr. if desired. -or longer to allow a good absorption from fractures.

The retrieval

1. Untie the tether (or liner) and extend it from the wellhead over the wellhead roller. Locate the winch plate (or other towing device) so that the tether/liner can be pulled from the well over the wellhead roller and beneath the small roller on the back of the well head roller. The current wellhead roller and winch system is called a “green machine”. BE CAREFUL to not drop the tether down the inside of the liner.

2. Lower a Grundfos or similar pump into the liner to remove the water. **Do not lower the pump below a point 5 ft or** more **above** the original water level in the hole (10 ft is better for 3-4" holes). This assures that the liner is always inflated. Pump the water from the liner until the pump runs dry. Immediately stop the pump. Never allow the water level inside the liner to be lower than 5 ft above the water table. A somewhat higher level is better insurance that the liner will not buckle in the hole and become jammed.
3. Winch the tether from the hole. This will go slowly for a time, but then it will be easier. This will take about 30 lb. of tension on the tether at the least. (note at about 150 lb. of tension on the winch, the crank is very hard to operate. Any additional tension is that needed to pull the water into the well.) The crank should be relatively easy to turn. Note, if the liner, and not the tether, is being pulled from the well, it may be easier to pull it out by hand without the winch, using several people to pull on the liner.
4. Wind the tether, and later the liner, on the shipping reel as it is pulled from the hole. Do not drag the liner on a rough surface (e.g., concrete, pavement, stubble, …) if the liner is to remain leak tight.
5. Adjust the pump speed to keep the water level a short distance above the pump. This will reduce the winching effort.
6. When the liner knot and valve appears at the surface (if the tether was being used to pull the liner), the liner may be able to be pulled from the well by several people over the roller.
7. When the liner reaches the depth of the water table, the pump can be removed from the liner. Do not pump out the last 5 ft of water in the liner. The water slug is needed to invert the liner.
8. Now the liner can be pulled from the hole without further pumping until the water begins to spill out the top of the hole. Lower the pump into the liner and remove the remaining water.
9. Pull the liner out of the hole.
10. Remove the clamps from the well head, and wrap the liner on the reel.

Examination of the liner

1. Pull the liner off the reel out on a relatively clean surface like a lawn or plastic film. Slide the liner off of the cover to expose the white backside of the cover. If the liner is very long, the liner may need to removed by bunching the liner, pulling the cover out, bunching the liner, etc… until the cover is removed. (the wet cover adheres a great deal to the wet liner,

so sliding a portion of the liner off the cover is easier.) (If the liner is not to be reused, it can be slit to expose the cover.) It is very helpful to insert a blower hose between the liner and cover to collapse the cover and inflate the liner before pulling the cover from within the liner. Spread the cover flat to allow easy examination of the white (unstriped) surface. Turn it over to examine the other side. When the cover is exposed to the end of the liner, the cover can be cut off to allow reuse of the liner to seal the hole.

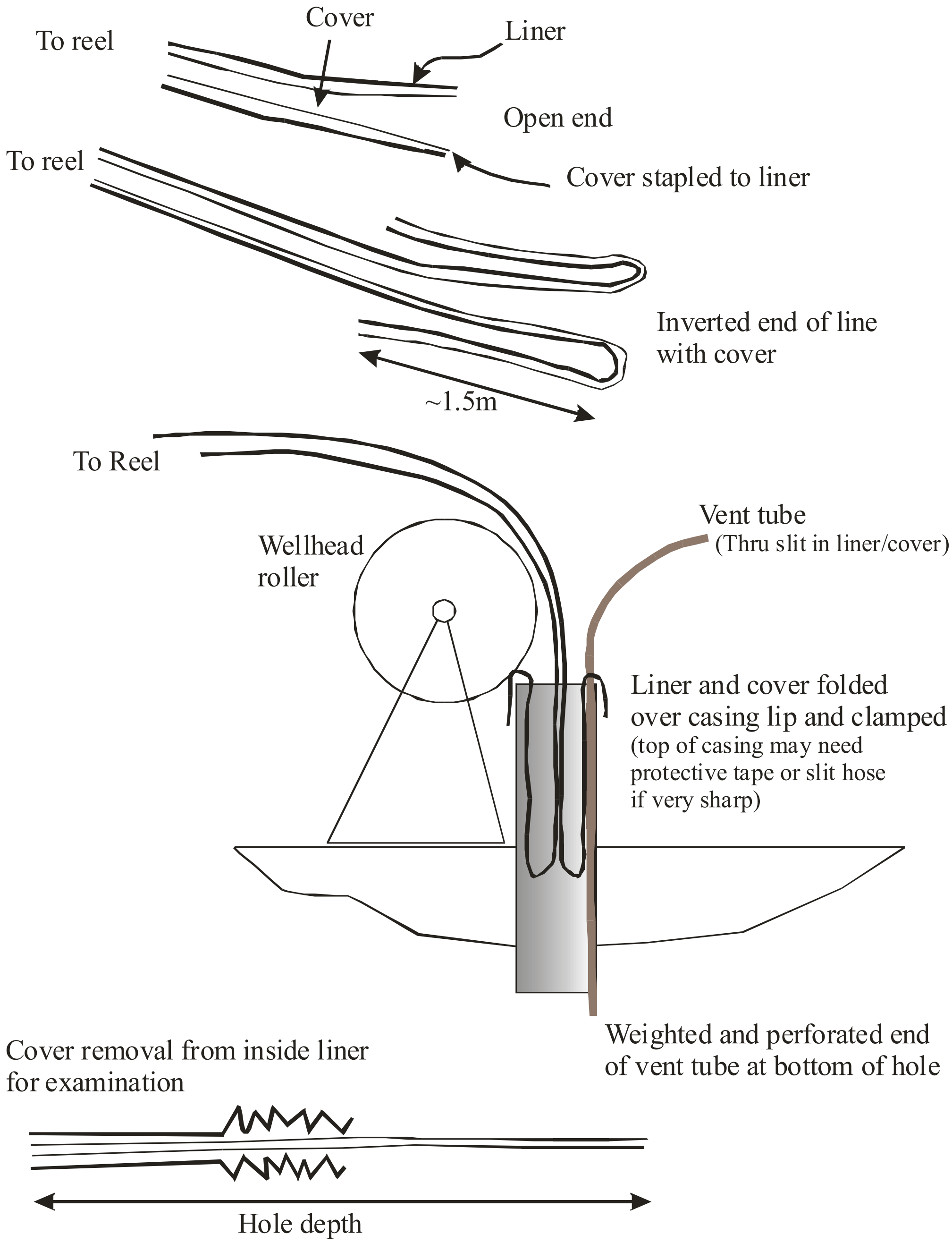
2. Lay a tape measure the entire length of the cover with the top at the ground surface position.
3. Record and photograph the location of any stains on the cover caused by the wicking of the dye through to the white side of the covering. The stains will be obvious. They will not be the faint variations of the dye lines that may be seen through the cover. If in doubt, expose a small piece of the cover to the pure product under water. For oily substances (non-solvents), the stains will be clear and translucent, like an oil drop on paper. If the NAPL is dark, the stains on the cover will also be dark.
4. The blank liner can be re-extended an replaced on the reel. The blank liner can then be reinstalled into the hole to seal it against flow in the open hole

If you have any questions, call FLUTe at 888-333-2433. Or call Carl Keller on his mobile phone 505-930-1154.

Note for installation in the vadose zone:

The procedure is the same except the water addition fills only 5 ft of the liner (10 ft for 4" holes). With the water in the liner allow the liner to evert to the bottom of the hole. Seal the top of the liner to an air blower of 1-3 psi capacity and inflate the liner against the hole wall for an hour. Then remove the air source and invert the liner from the hole by hand. Use gloves for the tether portion. Don't drop the tether and keep it anchored firmly to prevent loss down the hole (a very awkward situation). If the grip on the tether is lost, the liner will rapidly descend down the air filled hole taking the tether with it. Roll the tether and liner onto a shipping reel as it is being removed. If the liner is to be installed later to seal the hole, do not drag the liner on a rough surface. That will damage the coating and cause a leak.

NAPL FLUTe liner installation in open borehole



FACT (FLUTe Activated Carbon Technique) Installation

Standard Operating Procedure for a FACT (FLUTe Activated Carbon Technique) Installation

Standard Operating Procedure for the Installation of a FACT System

The following description is for the typical borehole for which the transmissivity profile is unknown since the FACT system is usually installed before a transmissivity profile is performed. The lack of information about the new borehole requires the assumption that the bottom end of the borehole is of low transmissivity.

Purpose

The FACT is a technology developed by FLUTe to map the relative distribution of dissolved phase contaminants in a sealed borehole with 6" to 3' resolution. The FACT works by adsorbing the contaminants from the rock matrix and fracture flows via diffusion, and is then analyzed via a MS/GC to produce a relative contaminant distribution profile.

Construction

The FACT is continuous strip of activated carbon felt which is attached to a NAPL FLUTe hydrophobic cover between the NAPL reactive cover and the diffusion barrier. The NAPL FLUTe and FACT are then attached to a standard blank FLUTe liner as a slip on cover which is fixed to the liner via a pigtail knot at the bottom end. This modified blank liner is sometimes called a carrier liner.

Shipping and Arrival at the Site

The FACT liner system is shipped to the site with the liner rolled on a shipping reel inside out with the open end of the liner on the outside of the roll. An air vent tube attached to the end of the liner is positioned at the edge of the reel for access to a vacuum source. The vacuum source is usually a venturi vacuum pump connected to a compressed air liner with a compressor

A pump tube is usually shipped on the exterior of liner roll. A metal rod weight is inserted into the pump tube. The rod must not be able to fall out of the pump tube. The end of the pump tube is covered with a plastic ball to avoid the entrapment of the tube as it is lowered to the bottom of the borehole. The pump tube is perforated with short scallops cut into the pump tube above the weight to allow easy flow into the pump tube.

Installation

The pump tube is lowered to the bottom of the hole, less one foot. The pump tube is secured to the top of the casing. Don't drop the pump tube into the hole.

The open end of the liner is extended from the reel, slipped over the top end of a surface casing and clamped. This usually requires a slit cut into the seam of the liner for passage of the top end of the pump tube. Be careful to not twist the cover material within the liner. (The cover is stapled to the top edge of the liner, unless the liner is shortened. The liner is then pushed down into the borehole about three feet or more to form an annular pocket between the liner against the casing and the inverted liner. The liner is sometimes inverted before being inserted into the casing and the open end is slit and then attached to the casing.

Water is added to the annular pocket providing a weight/pressure against the inverted end of the liner. The liner then everts down the borehole as it is fed from the shipping reel. A minimum of ~5 lb. of tension is maintained on the liner as it everts to the water table.

Once the end of the everting liner enters the water table in the borehole, more water is added to the liner driving it deeper into the borehole. Prior to further descent of the liner beneath the water table in the borehole, the vacuum pump should be connected to the hollow axle on the reel stand and the reel axle connected with a jumper tube to the vent tube at the side of the reel. The vacuum should be applied until the liner is visibly collapsed at the top of the surface conductor before more water is added to the liner. Then the water addition can proceed.

Once the liner has descended a short distance below the water table, a slender tube is inserted into the pump tube to form an air lift pumping system. The slender tube is installed to at least 3 times the depth to the water table, but not beyond the scallops in the pump tube, preferably 10 ft above the scallops. A compressed air source is connected to the slender tube to generate water flow from beneath the everting liner to the surface through the pump tube.

When the liner has everted to half its length into the borehole, the end of the liner descends into the borehole followed by the tether. The same tension is applied to the tether as the liner descends further.

If the liner is equipped with a water addition system for use during the removal of the liner, there is often a tube that descends with the tether as the tether is fed from the reel.

As the liner descends in the borehole, the water is removed from beneath the liner using the pump tube air lift system until the liner reaches the bottom of the borehole.

Once the liner has reached the bottom of the borehole, the flow from the pump tube will cease. At that point the tether is secured to a support bar placed across the casing. The support bar is provided with the liner as are the clamps for the casing.

Once the tether is supported, a pump must be lowered into the liner to remove water allowing the liner to collapse until the pump tube can be removed from the borehole. The liner is then refilled to 5-10 ft above the original water level in the borehole. This can take some time because the liner will dilate forcing the water trapped between the borehole and liner to be forced back into the formation. When the liner water level is no longer descending with the liner dilation, the cover and FACT are pressed against the borehole wall. FLUTe personnel may then perform a test to determine the highest head in the formation by lowering the water level in a stepwise manner until the water level no longer descends with water removal. That is the level of the highest head in the formation. The water level in the liner should then be raised to 5-10 ft above that level. Ten feet is preferred if available without overflow of the surface casing. If there is a substantial open hole in the vadose zone, the water level can be raised to 30 ft above the original water level to allow a FACT assessment of the vadose zone.

The liner is left in place for ~2 weeks.

The Removal Procedure

Then the liner is inverted from the borehole. If the bottom end of the borehole is impermeable, water must be added beneath the liner using the water addition system. This is best done by FLUTe personnel.

Upon the inversion of the liner from the borehole (normally performed using a FLUTe system called a “green machine”) the liner is extended on a poly-sheet on a flat surface. Air is blown into the liner between the liner and the cover material. (Note the cover is now inside the inverted liner.) The cover is removed from the liner by sliding the liner sequentially off the cover. The cover is then extended on the poly-sheet. The liner is then best slit from the top to the bottom opposite the FACT silver colored diffusion barrier. A tape measure is placed next to the flat liner in order to determine the depth of the NAPL stains on the cover. Those stains are best photographed with the tape in the photo. The top end of the tape should be positioned at the ground surface position on the liner when it was in the borehole.

FACT Sectioning, Preservation, and Lab Analysis

FLUTe staff will usually then remove the carbon felt from the diffusion barrier and places it in the prescribed lengths in bottles containing DI water for shipment to the lab for analysis. The bottles are labeled for depth in the hole, the hole ID and date and time. With quick removal from the diffusion barrier to the bottles there is minimal loss of VOCs in the carbon. The bottles are then placed in a shipping contain with ice for shipment to the lab.

For any questions about the procedure, contact Ian Sharp at 505-883-4032 or Ian@flut.com.

FLUTe Transmissivity Profile Information

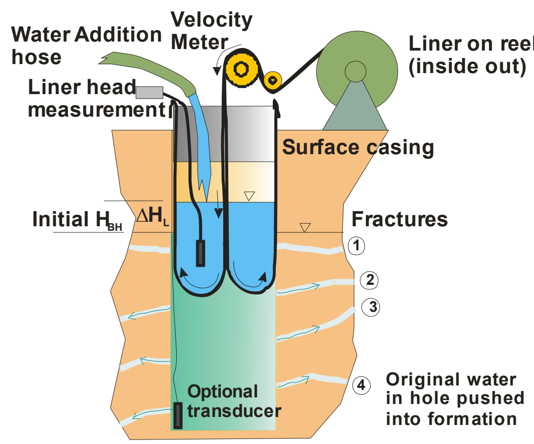
Information Available in a FLUTe Transmissivity Profile

Introduction

The FLUTe transmissivity profiling method is relatively new to the hydrologic community and sometimes not well understood. This paper describes how to use a Profile and how it compares to traditional measurements. The geometry of the measurement is shown in Fig. 1.

How the profile is measured

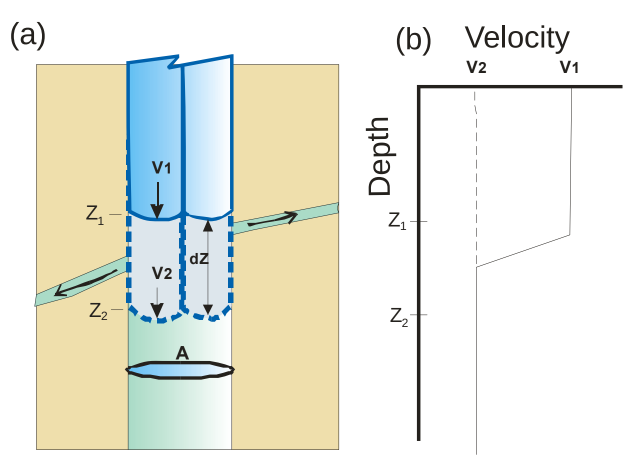
Fig. 1. Geometery of profile measurement



An ordinary FLUTe blank liner is installed in an open borehole to the water table. The liner is restrained and filled with water to a level 10 ft, or more, above the formation water table as tagged in the open hole. The liner is then released and the descent rate of the liner is measured as well as the head in the open hole beneath the liner. The water level inside the liner is maintained as nearly constant and well above the formation water table to develop a substantial overpressure in the borehole.

The release of the liner develops an instantaneous increase in the borehole pressure which causes a very steep gradient at the borehole wall and a large flow rate of water out of the borehole. That outward flow develops a lower gradient as the flow rate from the borehole approaches the steady state flow rate. The initial high flow rate rapidly decays to the steady state flow rate. Fortunately, that approach to the steady state occurs before the liner has descended more than 10-15 ft. typically, but can persist longer. That initial high flow is called the "transient." A correction for the transient will be discussed hereafter.

Fig. 2. Velocity change upon passing a fracture



Flow rate into the fracture, $\Delta Q = A(V_1 - V_2)$, where $V_1 > V_2$
$T = \Delta Q \ln(r_0/r_w)/(2\pi\Delta H_{BH})$ in the interval Z_1 to Z_2

As the liner descends by the eversion of the liner (the reverse of inversion), the water is driven from the borehole as rapidly as the transmissivity of the borehole allows. Initially, all the flow paths in the borehole are open and the liner descent is most rapid. However, as the liner descends, it sequentially seals, from the top down, the permeable features (fractures, bedding planes, or permeable beds). The sealing of each permeable feature reduces the transmissivity below the everting liner and the liner descent rate slows. That is the essence of the transmissivity profiling method. The velocity change as the liner seals a flow zone, when multiplied by the cross section of the borehole, is the flow rate of the feature sealed by the liner (Figure 2). In other words, the descending liner is essentially a flow meter which measures the flow rate out of the hole. Each time a permeable feature is sealed, the flow rate out of the borehole drops and so does the descent rate of the liner. A plot of the liner velocity with depth shows a monotonic decrease in velocity of the descending liner. Each decrease in velocity identifies the location of a permeable feature and the magnitude of the velocity change is a direct measure of the flow capacity of that feature. Figure 3 is a typical data set.

The calculation of transmissivity from the liner descent

The liner decent is measured by an encoder on a roller at the surface in the machine called a "Profiler". The encoder measures the liner depth every half second, typically. From the liner depth and the time is calculated the velocity of the liner as it travels that discrete depth interval. High in the hole where the liner is descending more rapidly, the interval traveled per time step is larger than it is deep in the hole where the liner is traveling more slowly. Therefore, the spatial resolution of the location of a permeable feature is better deeper in the hole. However, the distance traveled in a half second time step is usually less than a hole diameter.

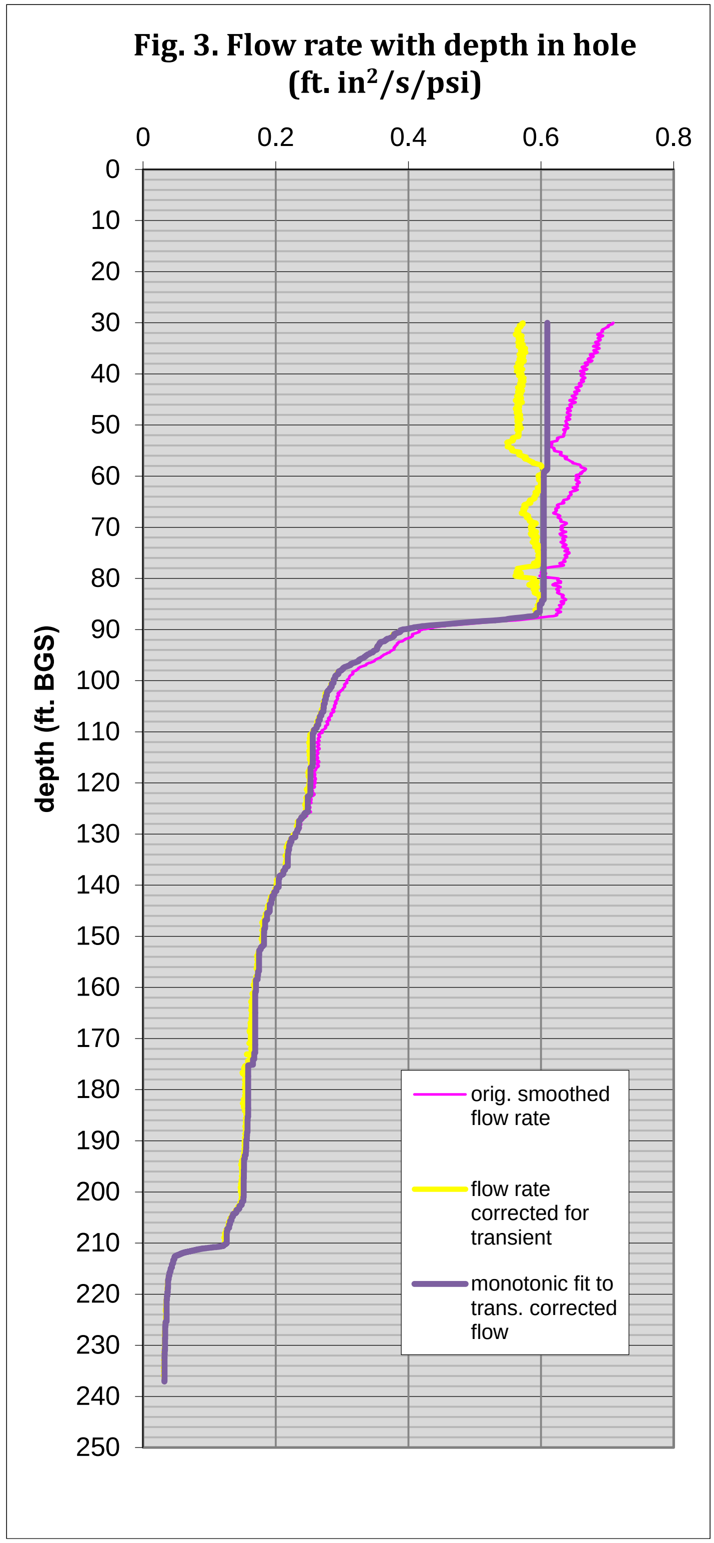
Because the driving pressure in the borehole is measured on the same half second time interval, the transmissivity can be calculated from the change in velocity as follows (The Thiem equation):

$T = \Delta Q/H \ \ln(r/r_0)/(2\pi)$, where $\Delta Q = \Delta v\ A$, where Δv is the velocity change over the interval traveled in a half second, and A is the borehole cross section. The ratio r/r_0 is the radius of influence divided by the borehole diameter. As with packer testing, r/r_0 is assumed to be constant. The term H is the measured driving head beneath the liner. From this simple expression, a transmissivity can be calculated for each interval of the borehole traversed in each half second. If there is no velocity change, the transmissivity is zero, within the limit of resolution of the measurement. Experience shows that the resolution is dependent upon the liner velocity and about 1% of the velocity.

The data as plotted in the Results Spreadsheet

The measurements are made in the English units so the flow rate out of the borehole is in ft/s in^2/psi which is a volumetric flow rate per unit driving pressure. That result is plotted in the first graph of the results sheet as the pink curve of Fig. 3. Because of the transient, the first portion of the pink curve is a steeply decaying flow rate which is not due to flow into the casing wall (the casing extends to 52 ft.). In those situations where the transient is obvious (e.g., a rapid decay in a surface casing before the liner enters the borehole) a first order correction is often made to the data to remove the transient effect on the velocity. That correction is made by calculating the transient to steady state in a 1D cylindrical geometry using the conductivity estimated from the borehole flow rate and an estimate of the storativity of the formation. There are several reasonable constraints on the transient correction. The subtraction of the estimated transient flow must not produce an increasing velocity with depth in the casing. In the casing, the corrected flow rate should be constant. When a casing measurement is not available (e.g., when the measurement is started below the surface casing), the constraint is only that the velocity should not increase with depth after the transient is removed.

The corrected flow rate in the example of Fig. 3 is the yellow curve. In this data set, the casing extends to 52 ft bgs and indeed the corrected flow rate in the casing from 30 to 52 ft. is relatively constant.



Another concern is that as the liner traverses an enlargement of the borehole, the liner dilates and the velocity of the descending liner must therefore decrease proportionately. As the liner exits the enlargement, the diameter will return to the nominal borehole diameter and the velocity will increase. This drop in velocity followed by an increase in velocity is ignored as unrelated to a flow zone associated with the initial drop in velocity. The method for ignoring such a temporary drop in velocity is to fit a monotonically decreasing curve to the data set. That curve is the black curve in Figure 3. The monotonic fit suggests that the portion of the borehole below the casing (30 to 52 ft.) has numerous extensive enlargements. Note, a 10% increase in borehole diameter will cause a 21% decrease in the liner velocity. Below 52 ft. the yellow curve and the black curve are essentially the same. The degree to which the yellow curve matches the black curve is a measure of the data quality and associated resolution. The transmissivity is calculated from changes in the flow rate of the black monotonic fit curve. If there is a permeable interval in the enlargement, the monotonic fit causes that transmissivity to be assigned to the upper portion of the enlargement where the initial velocity decrease occurred.

The drop in velocity from 52 to 54 ft. is typical of an enlargement below the bottom edge of the casing. The rise in velocity/flowrate from 54 to 58 ft is typical of the entrance of the liner into a borehole whose diameter is less than the casing.

The second graph of the result spreadsheet (Fig. 4) is the plot of the transmissivity calculated for each half second of travel down the borehole. Because the interval traveled per time step is longer at the top of the hole, the plot can be visually deceiving. The large drop at 90 ft is shown as a very large transmissivity whereas the major drop in flow rate at 212 ft is shown as many small transmissivities over very short intervals. In order to overcome that illusion, the fourth graph on the results sheet (Fig. 5) is an integration of the variable interval transmissivities in Fig. 4 over a constant interval, usually a one foot interval. This is the result expected if the transmissivity profile was determined by a continuous series of one foot straddle packer tests. Here the large flow at 90 ft in Fig. 5 is more clearly a large flow about twice that at 212 ft. Figure 5 may be the plot most easily compared to other measurements in the borehole. It is the plot of the data "sum over the interval" (col. U) versus the "depth of the interval" (col. V).

Fig. 4. transmissivity of discreet intervals

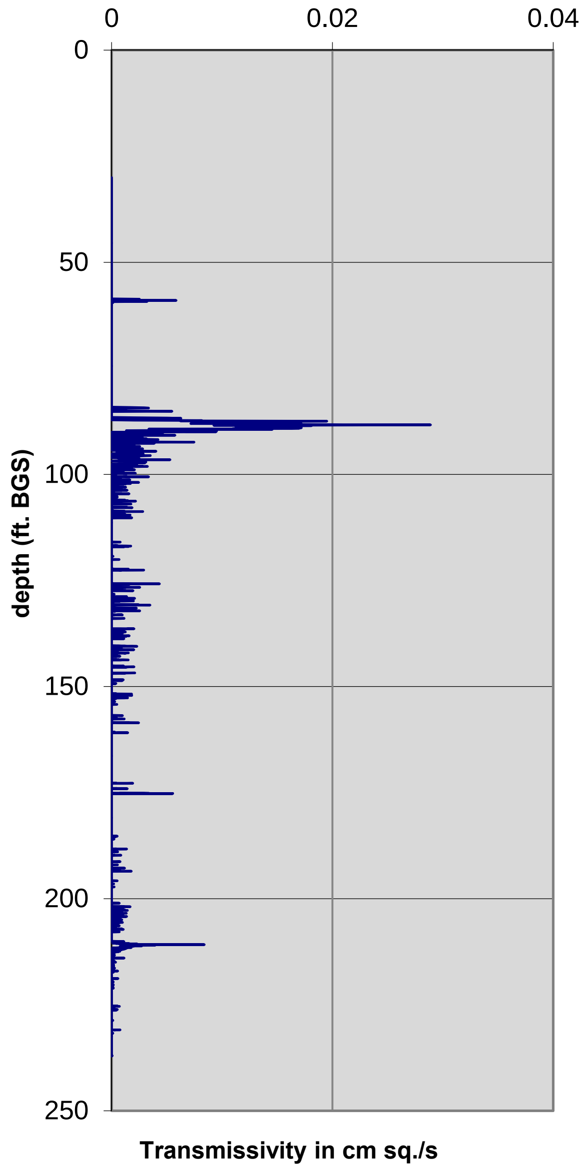
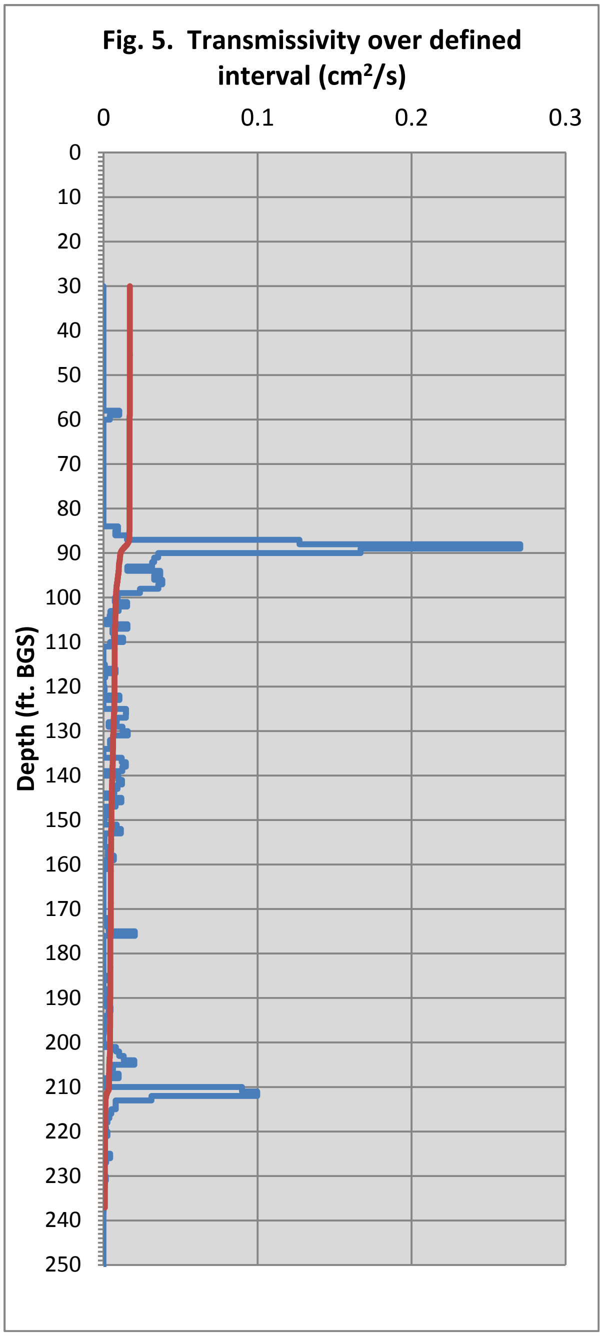
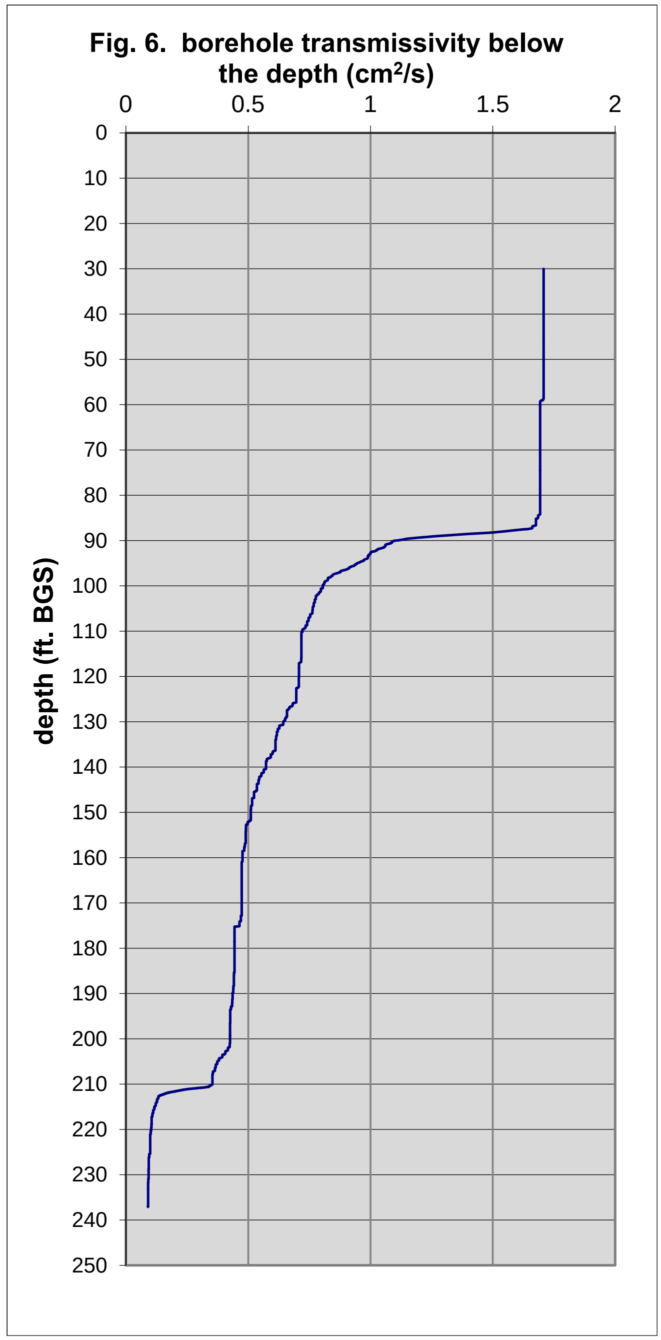


Figure 6 is the third graph of the "Results". This plot is the integral of the transmissivity data of the second curve (Fig. 4) from the bottom of the hole to the top of the hole. The result is identical to the monotonic fit curve of Fig. 3, but in units of transmissivity of the borehole below the indicated depth. Since the liner velocity is a measure of the transmissivity of the borehole beneath the bottom of the liner, Figure 6 should have the same shape as Fig. 3. The utility of Fig. 6 is that the transmissivity of any interval of the borehole is easily determined by the difference of values of Figure 6 between two depths. For example, the transmissivity of the interval between 93 ft (T=1 cm2/s) and 153 ft (T=0.5 cm2/s) is 0.5 cm2/s. The transmissivity of the interval from 84 ft to 93 ft is about 0.69 cm2/s. In this simple manner, one can determine the transmissivity of any interval in the borehole. Figure 6 is also helpful in that it is easy to see where there are very large flow zones, probably fractures, at 90 ft and 112 ft. The interval from 123 to 146 ft is a slope of more distributed permeability either as a matrix permeability or a pervasive fractured zone. In contrast, the interval from 160 to 170 ft. is relatively impermeable. The curve of Figure 6 is the plot of column T, the integral transmissivity below the liner, versus column O, the depth of the liner. The value of the integral transmissivity at the top of the hole is the total borehole transmissivity (1.7 cm2/s).





The red curve of Fig. 5 is the nominal resolution limit of the transmissivity data. The red curve is simply 1% of the value of the integral transmissivity of Fig. 6. In many situations, transmissivity peaks of Fig. 5

just below the red curve will match measured flow zones in the borehole. If the yellow curve of Fig. 3 is essentially the same as the black curve, the resolution limit is often better than the red curve on Fig. 5.

Conclusion

A particular advantage of the profiling technique is that the sum of the measured transmissivities is the transmissivity of the entire borehole. Such is not the case, for example, with straddle packer tests. If there is any leakage in the straddle packer tests due to a rough hole wall or bypass in the formation to the open hole above or below the packers, the total sum of the packer measurements will exceed the total borehole transmissivity.

Another significant advantage is that the transmissivity profile is a continuous measurement allowing the determination of the transmissivity of any interval in the borehole. Also, of course, the Profiling technique requires a very small part of the time required for detailed straddle packer testing of a borehole and much higher resolution than most packer tests.

A disadvantage of the profiling technique is if the borehole transmissivity is primarily due to a large fracture at the bottom of the borehole, the large velocity throughout the rest of the borehole down to that large fracture provides poor resolution of much less permeable flow paths in the upper portion of the borehole.

A detailed description of the transmissivity profiling method is available in a paper submitted to Ground Water by Keller, et al. The transmissivity profile is often used to determine where discrete sampling intervals should be located for assessing the extent and type of ground water contamination. The technique has also been used in conjunction with the Water FLUTe multilevel sampling and head measurement system to assess municipal ground water supplies and the hydrologic environment near mining operations. Any questions about the method or profiling results should be directed to info@flut.com or to 505-455-1300 or 505-930-1154.

Water FLUTe Installation Procedure

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For a medley of innovative designs
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505-455-1300, www.flut.com

Brief Description of Installation Procedure

for

Water FLUTes

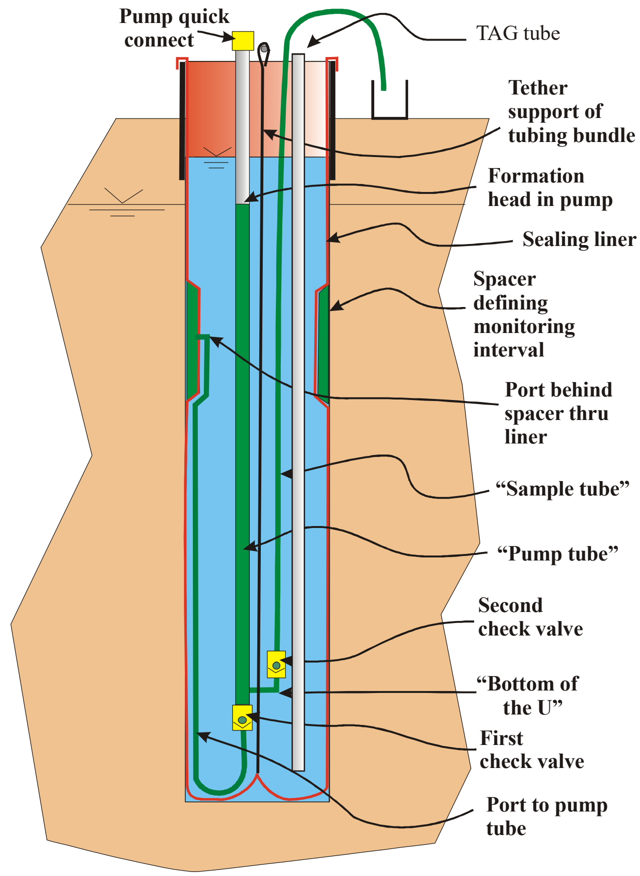
Installation procedure for Water FLUTes

Purpose
This is intended as a brief general description of the procedure and the equipment used for the Water FLUTe installation method.

The Water FLUTe system
The Water FLUTe system is a multi level ground water sampling system as is described in detail in Cherry, et al[1]. The system consists of a flexible borehole liner composed of a urethane coated nylon fabric with attachments for the purpose of drawing water from the formation and for measurement of the depth of the water table at each sampling interval. Figure 1 depicts the liner as fully installed in a borehole with only one sampling interval shown for clarity. The external annular spacer defines an interval of the borehole that is not sealed by the liner. The ground water sample is drawn from that interval and conducted to the pump system shown in the center of the borehole. The long pump tubing allows a relatively large (~1 gal.) sample to be displaced to the surface by nitrogen gas pressure. The pumping procedure allows a thorough purge of the pumping system and a water sample can then be obtained with essentially no risk of aeration of the sample. The water level at the port is measured with a manual electric tag liner lowered into the pump tube. Pressure transducers are often incorporated into the system to allow a continuous recording of the head variations in the formation.

Fig. 1. Water FLUTe pump system

(Single port system shown for clarity)



The installation procedure
The Water FLUTe system is everted into the borehole as is normally done for many flexible liner systems. Figure 2 shows the main components of the installation procedure (the pumping system is omitted from the drawing). The liner is positioned on a shipping reel near the wellhead. The liner is inside-out relative to its final state in the borehole.

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[1] *A New Depth-Discrete Multilevel Monitoring Approach for Fractured Rock,* Ground Water Monitoring & Remediation 27, no. 2/ Spring 2007/pages 57–70.

An air vent tube is first located in the borehole to allow the air above the water table to escape as the liner is installed. A second tube called a pump tube is lowered to the bottom of the hole to allow the water to escape beneath the liner as the liner is everted into the hole (eversion is the opposite procedure to inversion). The top end of the liner is fastened to the surface casing with a large hose clamp. Then the liner is pushed into the casing by hand for a depth of ~3 ft to form an annular pocket. Water is added to the annular pocket which pressurizes the liner and drives it down the hole, pulling itself off the shipping reel. The liner passes through itself and is said to be everting down the borehole. The water level inside the liner is well above the water level in the formation so that the liner interior pressure is higher than the formation pressure, causing a seal of the borehole. As the liner descends, it pushes the borehole water into the formation. If the formation is of low transmissivity, the water must be pumped from beneath the liner via the pump tube. When the liner reaches the bottom of the hole, the tether supporting the pump tubing is tied to a strong bar at the wellhead to prevent any further descent of the tubing bundle.

Fig. 2. Typical Water FLUTe Liner Installation

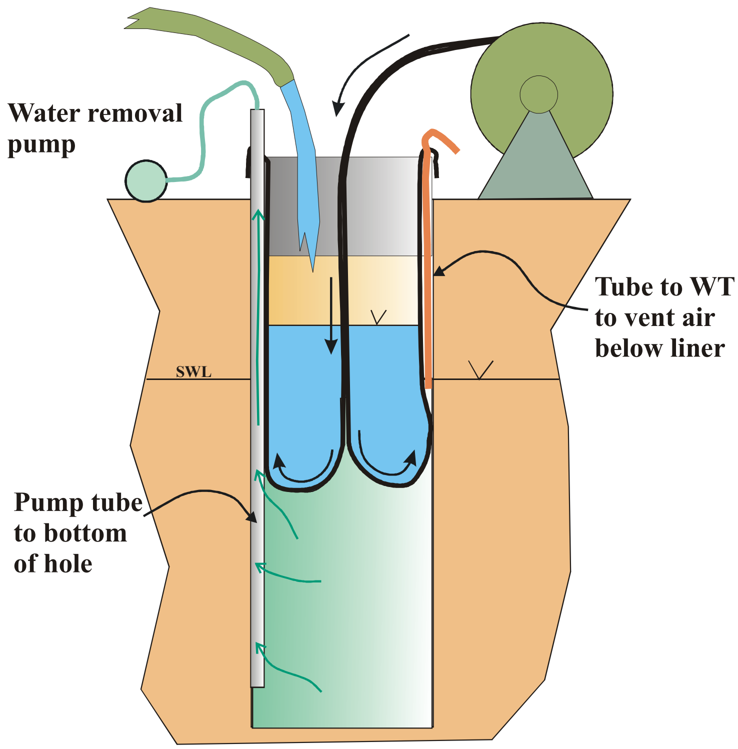


Figure 1 shows the liner fully everted and sealing the borehole. The individual pumping systems are tested to assure that they are fully functional before the pump tube is removed. In order to remove the pump tube, a pump is lowered inside the liner and the water is removed from the liner until the liner begins to collapse. (Sometimes a large tube built into the tubing bundle, called a tag tube, is used as an air lift pump to remove the water from the interior of the liner.) The pump tube is then pulled out of the hole and the liner is refilled to a level about 10 ft above the water table in the formation so as to pressurize the liner and seal the borehole. The sealing liner isolates each sampling interval in the hole to allow a discrete water sample to be drawn from that interval defined by the length of the annular spacer on the exterior of the liner.

The quick connect fittings are added to the top of the pump tubing for connection of the gas source. A nitrogen bottle is used to expel the water from the pumping system as shown in Figure 3.

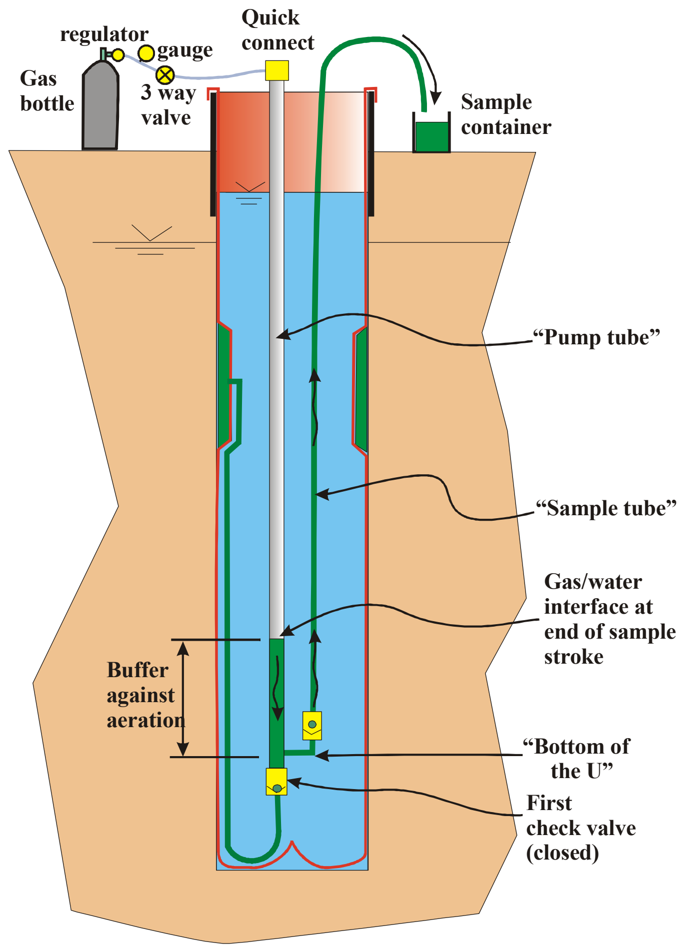
Special circumstances

If the water table is very near the surface, a temporary extension of the casing is added to develop a higher driving pressure for the installation of the liner. When the liner is fully installed, a weighted mud is used as a filling of the liner from the bottom to the top to better pressurize the liner. The mud still allows the liner to be removed by the reverse of the installation process.

In karst formations, a device called an eversion aid can be used inside the bottom end of the liner to cause it to propagate more nearly vertically than a liner driven with water alone. This allows the liner to propagate through large caverns intersected by the borehole.

Water FLUTe liners can be installed equally easily in angled holes or even horizontal holes using the same eversion procedure.

Fig. 3. Pumping Procedure



FLUTe Vacuum Water Level Meter Procedure

FLUTe – Flexible Liner Underground Technologies

The FLUTe Vacuum Water Level Meter

The vacuum water level meter (VWLM) is a very simple device that allows one to measure the depth to the water table (DTW) in a slender tube that cannot accommodate an electric water level meter. The VWLM is advantageous for any system that uses peristaltic pumping (DTW is less than ~25 feet below the ground surface).

How does the VWLM work?

The VWLM works similarly to the process of drinking a beverage through a straw. If you reduce the pressure at the top of the straw, the liquid rises into your mouth. The VWLM uses the same principal by applying a partial vacuum to the top of the sample tube.

A vacuum pump is connected to the sample tube and a vacuum is applied. The magnitude of the vacuum applied determines how high the water level can be raised above the water table. The vacuum is increased until the water shows in the sight glass (Figure 1.).

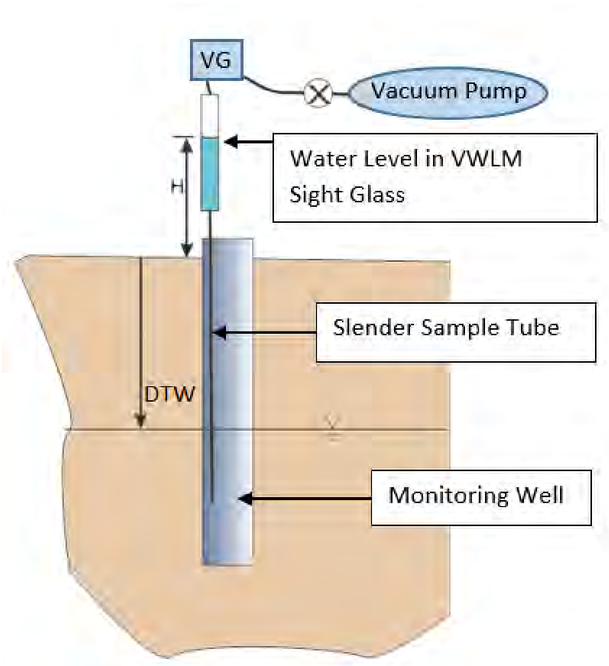


Figure 1. Vacuum Water Level Meter Design. Depth to Water (DTW) = Vacuum Applied (VG) – Height of Water in the Sight Glass Above Ground Surface (H).

Once the water rises into the site glass, the vacuum increase is halted by closing the valve to the vacuum source. The vacuum gauge (VG) displays the vacuum applied in units of feet of head that were required for the water to rise to the site glass.

Note, the level in the sight glass is well above the ground surface and therefore one must subtract the distance from the water level in the sight glass to the ground surface to find the DTW.

To calculate the DTW, simply follow the equation below:

DTW = VG (vacuum in feet of water) - H (height of water level in site glass above the ground surface).

To measure the DTW in another tube, such as that to a different port in a Shallow Water FLUTe multi-level system, simply drain the sight glass, connect to another sample tube, and repeat the process.

Water FLUTe Sampling Procedure

FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
For a medley of innovative designs
6 Easy St., Santa Fe, NM 87504
505-455-1300, www.flut.com

Sampling guidelines for *Water FLUTe* systems installed <u>after</u> May, 2009

Rev. April, 2010

Water level in the liner.

The liner water level should be ~10 ft above the highest formation water level to provide a good seal of the liner in the hole (5 ft minimum excess head). The formation water level can be measured via the "pump tube" for each port. The water level inside the liner should be tagged in the ½ x 5/8" tube labeled "TAG" adjacent to the sampling tubes. If the water level inside the liner is measured in the liner, outside the Tag Tube, lower the weighted tag line very slowly to avoid damage to the liner. Water can be added to the liner by simply pouring water into the liner or through the TAG tube, whichever is easier. Do not fill the liner more than 10 ft above the highest formation water level. The water level in the liner should be checked prior to each sampling episode. (Beware that filling the liner with de-ionized water can give a false water level reading.) It is not recommended to manually tag water levels more than 200 ft below the surface. The wet film adhesion may prevent the removal of the tag line. A special Teflon coated tag line can be used to extend that limit.

Water flow

The water flow into the pumping system is shown in Fig. 1. Water flows from the formation through the spacer pore space, through the port tube, through the first check valve, and fills the "pump tube". The "sample tube" is also filled at the same time. The water level rises in the pump tube to the water table for that port.

Setting up the gas pressure source

The water is pumped with gas pressure. The FLUTe pump design is such that there is very low risk of aeration of the sample. The gas source is usually a nitrogen bottle with a regulator for setting the prescribed driving pressure. The arrangement of the FLUTe gas drive system is shown in Fig. 2. The regulator is set to the proper gas pressure defined later by closing the three way valve to prevent gas flow out of the quick connect fitting. The

pressure gauge on the FLUTe pump driver is much more sensitive than the regulator for setting the regulator pressure. The FLUTe pump driver must be securely connected to the regulator at the normal ¼" NPT connection on the regulator outlet.
The regulator is first attached to the top fitting on the gas bottle (a special nitrogen regulator fitting connects to a nitrogen bottle). Tighten the nut securely. Turn the pressure regulator handle counter-clockwise until is moves freely (the no pressure position). Rotate the main valve on the regulator (nearer the bottle) clockwise to fully closed. Open the valve on the bottle (counter clockwise). The main bottle pressure gauge on the regulator will rise to the bottle pressure. Close the regulator valve (clockwise) until the pressure starts to rise on the pressure gauge on the FLUTe pump driver (three way valve closed with no flow out of the quick connect). Adjust the regulator to the desired pressure for purging, provided by FLUTe. Connect the quick connect to the top fitting of the pump tube (see Fig. 2). Open the three way valve to drive the water out of the pump.

Purging

Water is pumped from the tubing by applying the gas pressure to the interface at the static water level in the pump tube (Fig. 1 and 2). The water is driven down in the pump tube and up through the second check valve to the surface via the sample tube. By driving the water with a sufficient gas pressure (the "recommended purge pressure") to drive all of the water in the pump tube and the sample tube to the surface, the water in the pump tubing is nearly all expelled. The purge stroke (~1 gal. of water) is complete when gas is expelled from the sample tube following the water flow. The pressure in the system must then be vented (i.e., dropped to atmospheric by turning the three way valve to the vent position), to allow the pump tube to refill by flow via the port tube. The recharge flow from the port tube consists of the port tube water, the water in the pore space of the spacer, and water from the medium. Because of the relatively large volume in the pump tube, most of the recharge is from the medium. The recharge will take about as long as the first purge stroke. However, a low conductivity medium will require more time.

Purging the pump tube a second time will remove any of the water that has resided in the spacer and port tube volume. That is highly recommended, since the water resident in the tubing and spacer is probably not typical of the formation water. If the refill has been prompt, the second purge water volume will be similar to the first stroke. Two more purge strokes, for a total of four purge strokes, are recommended to remove water that may have been in long contact with the liner or spacer. (Note, systems manufactured before May, 2009 use larger pumps and were only stroked twice. The purge volume is slightly larger for this new procedure and takes about the same time as the two stroke system. This new system stresses the liner less at the spacer and has numerous other advantages.)

Sampling

The sampling flow is best driven on the fifth cycle using a "recommended sampling pressure" which is less than that needed to drive gas through the bottom of the pump tube. The pressure recommended is that which will drive the water to near, but not out of, the bottom of the large tube. That recommended pressure, "the sampling pressure," is calculated in the spreadsheet provided with each system. The pressure regulator is set to the sample pressure, which is lower than the purge pressure. Opening the three way valve will now apply the sample pressure to the system causing flow from the sample tube.

The first flow of the sampling cycle sweeps along droplets of water left in the tubing from the purge cycle. That residual water is depleted of volatile components. Tests have shown that the first tube volume of the sample flow should be discarded as depleted in volatiles (the "discard volume" is also calculated in the spreadsheet). Thereafter, the samples can be collected from the sample tube outflow. The volume to be discarded is shown in the spreadsheet as "discard volume". The sample tube water flow rate will start fast, then slow, and finally stop. That occurs as the water column being driven approaches the applied pressure/head. The typical sampling pressure drives to within 25 ft. of the bottom of the pump tube (the U). The large buffer zone remaining in the pump tube assures against aeration of the sample.

This procedure should provide an ample sample (~3 liters) of good quality drawn directly from the formation. If a larger sample volume is needed, simply drop the pressure (i.e., vent the three way valve again), let the pump refill and apply the pressure again. No discard is needed for subsequent sampling flows.

Caution: If the pumping system refills very slowly, there may not be sufficient water in the pump to fill the "sample tube" to the surface when the stroke is performed. In that case, there will be spitting of gas from the sample water and it will be followed by a flow of gas only. The sample water should never show "spitting" and the sample stroke should never end with gas flow from the sample tube. The proper sample flow will slow until it stops flowing. Should this evidence of insufficient recharge be observed, allow the pump to refill for a longer time and repeat the sample stroke. One can tag the water level in the large tube, as described in the head measurement procedure, to assure that the pumping system has been sufficient refilled.

Measuring the head in the system

The water level at each port can be manually measured by removing the plug from the top of the pump tube and lowering a slender (~1/4") electric water level meter until it contacts the water level in the pump tube. It is not recommended to manually tag water levels more than 200 ft below the surface. The wet film adhesion may prevent the removal of the tag line. A special Teflon coated tag line can be used to extend that limit.

The water level in the large tubes may not be the current water level. After sampling, if there is any leakage of the second check valve (sand in the tube, etc…) the water in the sample tube can backflow into the larger tube, adding to the water that fills the large tube during the recharge. Also, if the water level in the formation is dropping between head measurements, the water level in the pump tube will not follow the descent if the first check valve is a good seal. For these two reasons, and for the freezing concern below, it is best to finish the sampling stroke by raising the pressure to the "purge pressure" value to purge the pumping system of all water. Then upon refilling, the level is the current head for each port. If head measurements are made between sampling events, each port's pumping system should be first be purged one stroke to allow the tubing to refill to the current head value. Always replace the plugs in the top of the pump tubes when finished sampling.

If the water might freeze in the sampling tubing near the surface, purge the entire volume of water from each sampling line, after sampling, before leaving it. Use the recommended purge pressure to remove all water, not the sampling pressure. **Each line should be blowing gas when the purge is**

complete. If the tubes were purged after sampling prior to head measurements, that is sufficient.

Since the Water FLUTe uses PVDF tubing, the purge of the entire system after sampling should not be neglected, even if head measurements are not to be made. This removes the water column in the sampling tube. For deep water tables, the long term pressure of the standing water in the sampling tube might lead to excessive creep of the tubing which is susceptible to “cold flow”, a characteristic of Teflon like materials. (This is not a concern except for very deep water tables (>300 ft).

In most cases, the performance of a final purge of the system after sampling is useful, even if not essential.

Simultaneous purge and sampling of all tubes

The FLUTe pumping system for each port is essentially identical in length, pump volume and elevation in the hole. This allows all ports to be purged and sampled simultaneously for a great saving in sampling time. The only difference for simultaneous sampling is that the pressure source must include a tube to each port fitting at the wellhead. FLUTe offers a manifold pump driver system at extra cost (the single port driver is provided with the Water FLUTe). The recommended purge and sample pressures are the same as used for single port sampling.

In some cases, the buoyancy of the sampling system is so great when emptied of water during the simultaneous purge that the tubing bundle can cause the liner to invert. The sampling volume spreadsheet provided with the liner notes whether the system can be purged simultaneously. This is only a problem for smaller hole diameters, many ports, and a small excess head in the liner. The new pump design allows simultaneous sampling in most situations.

A short summary is provided as the following checklist:

<u>Check List</u>

1. Check/restore the water level in the liner.
2. Connect the gas driver source to the gas drive (pump) tube for the port.

3. Set the regulator to the recommended purge pressure.
4. Turn the three way valve and expel the tube water at the suggested purge pressure. Collect the purged water volume for verification of a good purge. Note the water flow time of the purge stroke (~4 min.).
5. Allow the tubing to refill. Repeat the purge. Collect the purge volume to assure the amount removed is at least the "port tube volume". Was the refill long enough?
6. Purge a total of four times, more if desired.
7. Allow the tubing to refill for the sample stroke.
8. <u>Reduce the driving pressure</u> to the "sampling pressure". Apply the pressure and collect the first flow to measure the discard volume. Discard that water. Collect the samples.
9. Perform a final purge of the water out of the sampling lines by raising the driving pressure to the purge pressure value.
10. When the sampling system has refilled, tag the water level, if desired, for the current water table. If a port system is refilling very slowly, tag it at a later time.

See the spreadsheet provided with each *Water FLUTe* for the recommended purge and sampling pressures. Those are the pressures that can also be used for a simultaneous purge of the several ports. The spreadsheet flags the condition where all ports should not be purged simultaneously. In most cases, several, to all, of the ports can be purged simultaneously.

Optimum sampling procedure:
Since it is often desirable to minimize the amount of time that the sample water resides in the pumping tubing, it is useful to note the actual time that is required for the recharge of the system. Since the fill rate slows dramatically for the last portion of the recharge, it is not necessary to wait for a complete refill. For most formations, the recharge is dominated by the tubing pressure drop. In that case, the time required for the purge stroke to be completed is about the same time required for the refill. (The exception is for a tight formation that recharges the tubing very slowly.) Hence the second purge can be started after waiting the same length of time as the first purge endured. If the second purge is of a similar volume (usually somewhat less) than the first purge volume, the refill time was long enough. After the same delay, the sampling stroke can be initiated. This timing of the strokes allows one to reduce the retention time in the pumping system. For the very large sample volumes produced, the refill time can be shortened

even more, as long as the sample volume is adequate after the discard of the first flow.

In some situations, the retention time is still too long. FLUTe can often increase the sample tube and port tube diameters for greater flow rates. However, the standard design is well matched for to a wide range of hole diameters, depths, and water table elevations. For very deep wells, the tubing may need to be of higher pressure capacity for the required driving pressures. For water table depths below 700 ft., this may be a concern. FLUTe initiated a design change from Nylon 11 to PVDF tubing in the Water FLUTe systems in 2002 to avoid any concern about tubing interaction with the sample water. However, the prescribed purge is sufficient for the use of Nylon tubing systems.

For special situations such as a very large difference (>50ft) between the water tables at the ports or large fluctuations in the water table, the pumping system may be extended to greater depths. However, the sampling procedure above is sufficient for that situation also.

Questions: Call 888-333-2433 and ask for Carl Keller, or a field engineer.

Figure 1. Water FLUTe pump system

(Single port system shown for clarity)

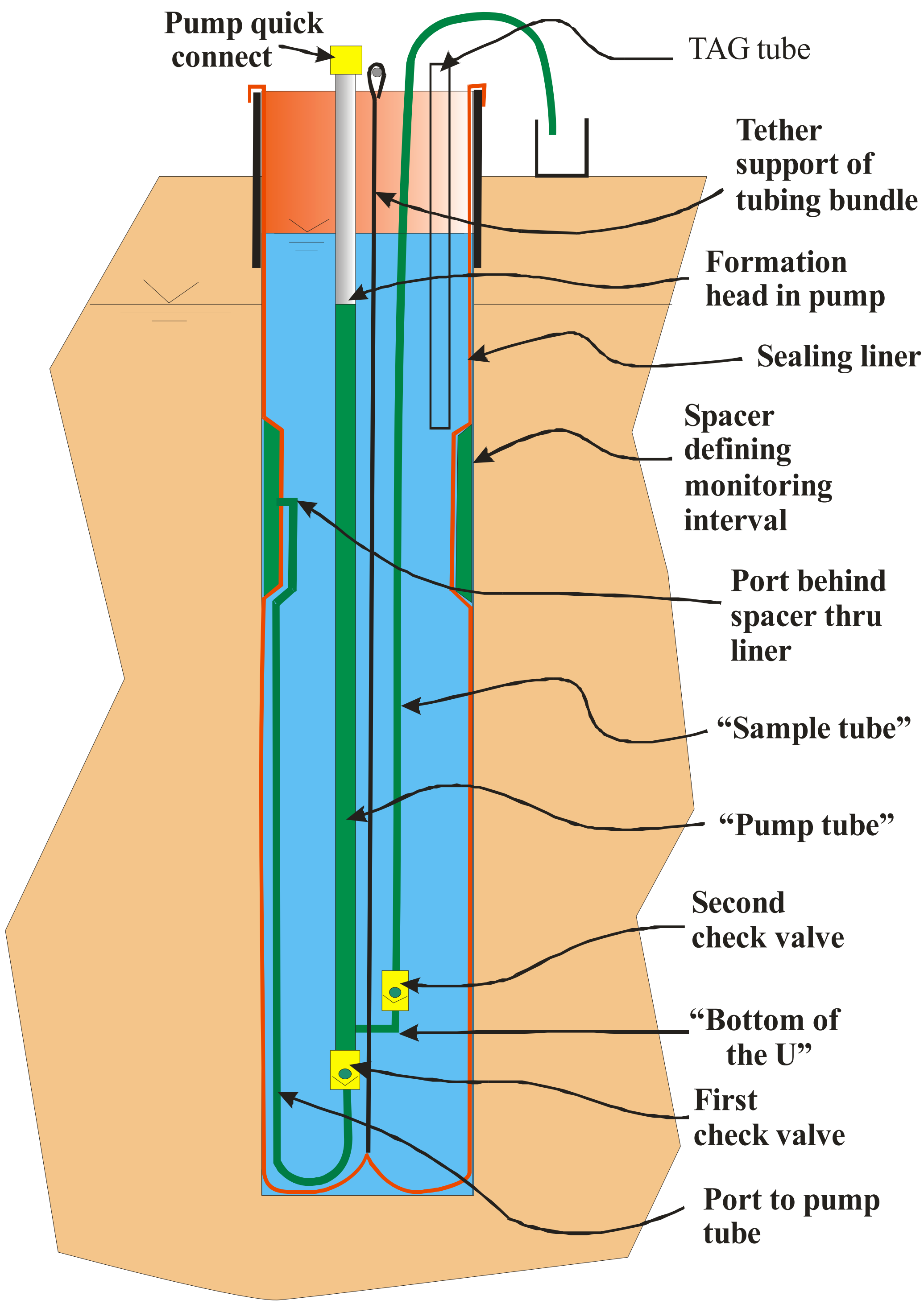


Fig. 2. Pumping Procedure