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Transmitted Via Federal Express

January 31, 2014

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Subject: Former Baron Blakeslee Site
Tax Map ID No.: 198-4-4.1
Property County: Suffolk
BCP Site No.: C152204-11-13

Dear Bob, Dena and Krista:

Per the Brownfield Site Cleanup Agreement, enclosed please find General Electric Company's ("GE") Pre-Design Investigation Work Plan for the Former Baron Blakeslee Site.

If you have any questions, please call me at (518) 862-2717.

Sincerely,

John

John M. Uruskyj
Senior Project Manager

cc:
Eric Merrifield, Esq., GE
Marian Whiteman, Esq., GE
Dean Sommer, Esq., Young Sommer

Pre-Design Investigation Work Plan
Former Baron Blakeslee Property
Site #C152204
Bay Shore, Suffolk County, New York

Prepared for

General Electric Company

Albany, New York

January 2014

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Albany, New York 12203

January 2014

Project Number: 145539

Brown and Caldwell Associates

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Certification Statement

I, Frank Williams, certify that I am currently a Qualified Environmental Professional as defined in 6 NYCRR Part 375 and that this Pre-Design Investigation Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

Frank Williams

Frank J. Williams, PG (specific states)

January 31, 2014

Date

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List of Abbreviations

AAR	Alternatives Analysis Report
BCA	Brownfield Cleanup Agreement
BCP	Brownfield Cleanup Program
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CVOC	Chlorinated Volatile Organic Compound
DCE	Dichloroethylene
DEC	New York State Department of Environmental Conservation
DOH	New York State Department of Health
DQO	Data Quality Objective
DUSR	Data Usability Summary Report
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Approval Program (NYSDOH)
EM	Electromagnetic
EPA	United States Environmental Protection Agency
eV	Electron Volt
FSP	Field Sampling Plan
GAC	Granular Activated Carbon
GC/MS	Gas Chromatography/Mass Spectrometry
GE	General Electric Company
GIS	Geographic Information System
GPR	Ground Penetrating Radar
HASP	Health and Safety Plan
HHEA	Human Health Exposure Assessment
IDW	Investigation Derived Waste
IRM	Interim Remedial Measure
LCS	Laboratory Control Spike
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	mean sea level
NAPL	Non-Aqueous Phase Liquid
O&M	Operation and Maintenance

PCE	Perchloroethylene
PDI	Pre-Design Investigation
PDF	Portable Document Format
PID	Photoionization Detector
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RD	Remedial Design
RWP	Remedial Work Plan
SAP	Sampling and Analysis Plan
SC	Site Characterization
SCDH	Suffolk County Department of Health
SCGs	Standards, Criteria and Guidance
SCO	Soil Cleanup Objective (NYCRR Part 375-6)
SCWA	Suffolk County Water Authority
SMP	Site Management Plan
SVE	Soil Vapor Extraction
SVI	Soil Vapor Intrusion
TAL	Target Analyte List
TCE	Trichloroethylene
TCL	Target Compound List
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

Section 1

Introduction and Purpose

This Pre-Design Investigation (PDI) Work Plan has been prepared pursuant to the Brownfield Cleanup Agreement (BCA) between General Electric Company (GE) and the New York State Department of Environmental Conservation (DEC), dated December 31, 2013 (Index C152204-11-13). The PDI Work Plan is a follow-up to extensive Site Characterization {“SC”} work that was conducted under an Order on Consent prior to the site’s entry into the Brownfield Cleanup Program. Based on the results of the SC, soil vapor extraction (SVE) was identified as a potential Interim Remedial Measure (IRM) that could be considered to address residual contaminant conditions at the site.

The BCA sets forth GE’s obligations under the DEC’s Brownfield Cleanup Program (BCP) for remediating the site known as the Former Baron Blakeslee Property, located at 86 Cleveland Avenue, Bay Shore, Suffolk County, New York (hereinafter, Site). The principal goal of this project is to select and implement a remedy that is protective of public health and the environment, taking into account the current, intended and anticipated industrial use of the Property; and to enhance the opportunities for the largely vacant, underutilized Site to be put back into productive use. To this end, the project is expected to further delineate and remediate the residual volatile organic compound (VOC) impacts in on-Site, unsaturated soils.

The overall scope of this BCP project consists of the tasks listed below. The tasks following the PDI will be addressed in future submittals.

1. Develop a PDI Work Plan to further delineate the extent of residual VOC impacts in shallow soil, determine the spacing of SVE points, and evaluate other design criteria including SVE system components.
2. Implement the Pre-Design Investigation.
3. Prepare an Alternatives Analysis Report (AAR) and draft Remedial Work Plan (RWP). The AAR/RWP submittal will include the results of the PDI as well as a qualitative human health exposure assessment (HHEA) based on the SC and PDI data. The AAR will consider both the unrestricted and industrial use scenarios. The draft RWP will be a conceptual level document and serve as the remedial design work plan. It is anticipated that the RWP will provide the framework for implementation of the aforementioned SVE system, implementation of institutional controls, and preparation of a Site Management Plan (SMP).
4. Prepare a Remedial Design. Following DEC and New York State Department of Health (DOH) approval of the RWP, a detailed Remedial Design (RD) will be prepared in accordance with the requirements of DER-10 (DEC, 2010) and submitted for DEC approval. The RD will include a draft Operation and Maintenance (O&M) Plan specifying periodic SVE performance monitoring and reporting requirements.
5. Implement remedial construction. The SVE system, whether implemented as an IRM or pursuant to an RWP, will be installed and subjected to initial testing to verify that it is achieving the specified performance criteria.
6. Continued SVE operation, maintenance, monitoring and periodic reporting will be conducted in accordance with the O&M Plan included in the SMP.
7. The DEC will be granted an environmental easement on the Property.

The specific remedial objective is to reduce the mass of the VOCs in the unsaturated zone at the Site, and consequently to reduce the corresponding VOC impacts to soil vapor. It is anticipated that a SVE system will be used to accomplish this objective. The objective of the PDI includes obtaining information that will allow for the design of the SVE system. The PDI will focus the following aspects:

- Delineating the source area of the VOC soil vapor impacts; and
- Obtaining SVE design information (e.g., extraction rates, spacing of extraction facilities, VOC mass loading, pressure distribution in subsurface).

PDI tasks to achieve these objectives are described in detail in Section 3 of this work plan.

Section 2

Site History and Description

This section describes the Site and the industrial area in which it is situated, the Site's history, and prior remedial actions and investigations.

2.1 Location

The industrial zoned Site consists of approximately 1.84 acres located at 86 Cleveland Avenue in an industrial-zoned area of the Town of Islip (Figure 2-1). The Site includes a +47,000 square foot building, comprised of three interconnected buildings constructed of concrete block and corrugated steel on concrete slabs (Figure 2-2). The grounds consist of asphalt-paved parking and driveway areas with landscaped and limited vegetated areas occurring along the northern, eastern, and southern Site boundaries. A chain link fence separates the abutting commercial and industrial properties to the west and south from the Site. A small portion of the building is currently occupied by a GE appliance repair shop, while the remaining areas of the building are unoccupied and vacant. The Site is currently serviced with municipal water from the Suffolk County Water Authority (SCWA). Public sewer services are not available in the area, and the Site utilizes a SPDES-permitted septic system.

The surrounding properties are used for commercial/industrial purposes including, but not limited to, chemical manufacturing, wood working and metal operations, vehicle maintenance/transmission shops, recycled materials and concrete production. The Site is surrounded to the north and across South 3rd street by an unimproved lot utilized for the parking/storage of school buses, and to the east and across Cleveland Avenue by a commercial building associated with school bus maintenance (190 Fehr Way) and Precision Metals Corp (221 Skip Lane), a sheet metal company. The Site is abutted to the west by a concrete, gravel and soil recycling center (3rd Street Recycling & Materials LLC) and to the south by a redi-mix concrete facility operated by the Deer Park Sand and Gravel Corp (90 Cleveland Avenue). The Site is currently serviced with municipal water from the Suffolk County Water Authority (SCWA). Public sewer services are not available in the area, and the Site utilizes a SPDES-permitted septic system.

The nearest residential area is located approximately 1,500 feet east of the Site. The nearest recreational area is the Oak Brush Plains State Preserve, located approximately one-half mile northwest of the Site. The preserve consists of pitch pine-scrub oak barrens, and is habitat for common animal species, including several types of warblers, red-tailed hawks, eastern cottontail, red fox and hognose snakes. Several species of rare invertebrates are present, including the coastal barrens buckmoth. The Site does not contain any wetlands, critical habitat or important natural resources.

2.2 History

The following table summarizes Site ownership since approximately 1969. More details are available in the SC reports (BC, 2012, 2013).

Owner	Begin Date (approx.)	End Date (approx.)	Notes
Standard Precast Products Corporation	Unknown	September 1976	Operations unknown. Circa 1969 aerial photograph shows a receiver and hopper in the central-eastern portion of the Site, and storage of finished products and wire mesh.
Purex Corporation	September 1976	August 1982	Under Purex ownership, a warehouse/shop building was constructed in the southwestern portion of the Site and an office building was constructed in the northeastern portion of the Site.
Baron Blakeslee Inc./Purex	August 1982	June 12, 1984	Baron Blakeslee Inc. was a division of Purex Corporation. The Site operated as a solvent/chemical storage, repacking, and distribution center. Operations reportedly closed in April/May 1983.
Town of Islip Industrial Development Authority (IDA)	June 12, 1984	November 1991	Aircraft Turbine Services (ATS), a subsidiary of Airwork Corporation/Purex Corporation, became a tenant of the Site in 1985 and assumed responsibility of ongoing environmental remediation.
Aircraft Turbine Services	November 1991	July 1994	ATS purchased the Site from the IDA.
UNC Accessory Services NY/CAMCO (UNC)	July 1994	1997	UNC purchased the Site from ATS.
Greenwich Air Services, Inc.	1997	1997	UNC became a subsidiary of Greenwich Air Services, Inc. in 1997
General Electric	1997	Present	1997 Greenwich Air Services acquired by GE, renamed GE Engine Services. Operations reportedly ceased by April 1998.

During the Purex/Baron Blakeslee ownership, the Site was operated as a solvent/chemical storage, repacking, and distribution center. Materials reportedly handled at the Purex/Baron Blakeslee facility included solvents, chlorinated hydrocarbons, fluorinated hydrocarbons, aromatic hydrocarbons, aliphatic hydrocarbons, ketones and glycols. The materials were reportedly transported to the Site in bulk tankers and 55-gallon drums; transported from the trucks and within the warehouse building via “fill and draw distribution piping” and portable tankage; and stored onsite in 29 ASTs and in 55-gallon drums. The solvents/chemicals were then transferred to smaller drums or tankers for delivery to customers. Purex/Baron Blakeslee reportedly utilized a bulk storage area in the southwestern portion of the Site, referred to as the “Tank Pit.” A secondary concrete containment area reportedly surrounded the Tank Pit.

Aircraft Turbine Services (ATS), a subsidiary of Airwork Corporation/Purex Corporation, conducted aircraft engine maintenance operations, including cleaning processes for steel, aluminum and magnesium parts that involved immersion in 400-gallon open process tanks containing various cleaning solutions and sodium hydroxide and water. Used solutions were reportedly pumped into drums, classified and disposed of off-site by a registered disposal contractor (Chemical Pollution Control, Inc.). While awaiting pickup for disposal, the waste fluids were reportedly stored in the rooms where the cleaning tanks were located.

Operations conducted by UNC do not appear to have involved extensive use of chlorinated solvents and there are no records or reports reflecting the release of hazardous substances or spills on the Site during or after UNC operations. Aircraft accessory equipment was reportedly cleaned in dip tanks, and other operations included shot blasting and painting. An interim permit (050491) for UNC to operate as a hazardous/toxic material storage facility was issued by the Suffolk County Department of Health (SCDH) on August 26, 1996 and listed 10,000 and 550 gallons of diesel fuel, 1,500 gallons of unspecified “organic solvent”, and 2,420 gallons of drum storage.

2.3 Prior Investigations

The Site has been the subject of a recent Site Characterization (SC) investigation conducted and completed pursuant to an Order on Consent and Administrative Settlement between the DEC and GE, dated September 27, 2010. Earlier groundwater remediation, including a pump and treat system, had been conducted by the prior owner/operator to address historic solvent-related impacts in groundwater. The SC Order on Consent and Administrative Settlement noted that the Applicant acquired the Site after the time that hazardous substances had been released on the Site. The objectives of the SC were to determine the nature of remaining contamination attributable to the former historic solvent storage and distribution operations within soils and groundwater underlying the Site, and to evaluate the potential for intrusion of soil vapor into the existing building from such residual historic conditions. The SC investigation was conducted from 2011 to 2013, and included the following:

- Extensive groundwater profile sampling and analysis for VOCs and metals;
- Supplemental groundwater sampling and analysis for metals via conventional monitoring wells;
- Sampling of soil gas at sub-slab and exterior locations (on- and off-site);
- Indoor/outdoor air sampling and analysis for VOCs; and
- Sampling and analysis of shallow (vadose zone) soils for VOCs.

The key SC findings were:

1. Groundwater samples from the vertical profile boreholes confirmed the effectiveness of the earlier groundwater treatment system, with only trace concentrations of VOCs detected in shallow groundwater.
2. Sodium was the only dissolved metal present in groundwater above Part 703 standards, with the highest concentration found upgradient, near South Third Street. The metals concentrations previously detected in direct-push groundwater profile samples were artifacts of high sample turbidity.
3. Soil samples from borings advanced inside the building indicate the presence of residual chlorinated VOCs (CVOCs) in vadose zone soils in a localized area mainly beneath the former Baron Blakeslee warehouse building in the southern portion of the facility (Figure 2-3).
4. Sub-slab soil vapor sampling detected Perchloroethylene (PCE) and Trichloroethylene (TCE) at concentrations for which DOH guidance recommends mitigation to minimize potential soil vapor intrusion. The TCE and PCE vapors are desorbing from shallow, vadose zone soils under the building. Indoor air data indicate the concrete floor slab is significantly restricting or eliminating vapor intrusion.

5. Exterior soil gas data indicated PCE and TCE vapors diminish away from the building but may be migrating toward Cleveland Avenue. Concentrations on the near side of Cleveland Avenue are generally 1 to 2 orders of magnitude lower than those under the building, and have generally diminished an additional order of magnitude along the far side of Cleveland Avenue.

2.4 Conceptual Site Model

The SC activities conducted from 2011 to 2013 the present included a review of historic information and environmental data, and the analysis of soil, groundwater, soil vapor and air samples. The information assembled and reported support a conceptual site model incorporating limited impacts by chlorinated VOCs in soil and soil vapor.

The former Baron Blakeslee facility consists of a slab-on-grade structure situated over relatively permeable glacial outwash deposits known collectively on Long Island as the Upper Glacial Aquifer. Groundwater in the Upper Glacial Aquifer is unconfined, with the water table at the site approximately seven to ten feet below ground surface. In this part of Long Island, groundwater generally flows south and discharges along the south shore. In the immediate vicinity of the site, groundwater flows southeasterly.

Historical industrial processes on the Site resulted in the release of chlorinated solvents to the subsurface soils and groundwater beneath the building. However, extensive vertical profile sampling of groundwater in 2011 demonstrated that little or no solvent impacts remain in the groundwater, a result of several factors including the elimination of infiltration by precipitation afforded by overlying structures and paving and the resulting restriction of leaching beneath the buildings, and the operation of an on-site groundwater pump and treat system by a previous Site owner for a number of years. Elevated concentrations of a number of metals were found in the vertical profile samples; however, subsequent installation of conventional monitoring wells and sampling by conventional low-flow procedures demonstrated that sodium is the only dissolved metal present in groundwater above Part 703 standards, with the highest concentration found upgradient, near South Third Street.

Soil samples from borings advanced inside the building indicate the presence of residual CVOCs in vadose zone soils in a localized area mainly beneath the former Baron Blakeslee warehouse building in the southern portion of the facility. The relatively low soil concentrations indicate that the residual CVOCs have degraded naturally and desorbed into soil vapor. Indoor air concentrations of the CVOCs are several orders of magnitude lower than the soil vapor concentrations and are comparable to outdoor air concentrations, indicating that the floor slab is greatly restricting or eliminating intrusion of the soil vapors.

Exterior soil vapor concentrations diminish significantly with distance from the source under the building. Concentrations on the near side of Cleveland Avenue are generally 1 to 2 orders of magnitude lower than those under the building, and have generally diminished an additional order of magnitude along the far side of Cleveland Avenue.

Section 3

Work Plan Objectives, Scope, and Rationale

As previously noted, the remedial objective is to reduce the mass of the VOCs in the unsaturated zone at the Site, and consequently to reduce the corresponding VOC impacts to soil vapor and the attendant migration of VOCs in the vapor. It is expected that a SVE system will accomplish this objective.

The SC data indicate that soil vapor impacts extend beyond the limits of soil impacts. Vapor concentrations in the source area are on the order of 10^4 - 10^5 micrograms per cubic meter; concentrations in the reminder of the site are on the order of 10^2 – 10^3 micrograms per cubic meter. Further soil vapor sampling is unlikely to improve the understanding of the source or the conceptual site model.

The objective of the PDI is to obtain information that will allow for the design of the SVE system. Specifically, the PDI will:

1. Further delineate the source of the soil vapor impacts.
2. Obtain SVE design information including extraction rates, spacing of extraction facilities, VOC mass loading, and pressure distribution in the subsurface.

The investigation tasks are described in the following subsections.

3.1 Standard Operating Procedures (SOPs)

Standard Operating Procedures (SOPs) for the following tasks are contained in Appendix B:

B-1	Investigation-Derived Waste Handling
B-2	Soil Sampling
B-3	Field Equipment Decontamination
B-4	Field Instrument Calibration
B-5	Direct Push Drilling
B-6	Canister Sampling Methodology

3.2 Utility Mark-Out and Clearance

Prior to conducting any of the intrusive activities described below, the locations of subsurface utilities will be marked in the field. UFPO/Dig Safely New York will be contacted at least 3 full working days prior to mobilization to the site to request that the local utility companies (i.e., gas, electric, telephone, cable, water, sewer, etc.) mark-out and provide clearance for their respective utilities. Some of the proposed drilling locations may be adjusted to provide adequate clearance from utilities.

3.3 SVE Testing

SVE testing will be conducted to obtain information that can be used to design the system.

3.3.1 Location and Layout

The SVE system will be located in the source area, which extends under the appliance repair shop and the central southern portion of the main building. The repair shop is an active business while the main building is not occupied. The location of the SVE test, including the extraction well, will be primarily in in the area of the appliance repair shop, where the highest VOC concentrations have been identified (see Figure 3-1). At least one monitoring point will be installed north of the partition between the repair shop and the main building to evaluate the effect of the foundation on subsurface air flow. A schematic diagram of the test set-up is shown on Figure 3-2.

There is a potential for test results obtained in the area of the appliance repair shop to not be entirely representative of conditions under the main building. The buildings were constructed separately, and the available soil data indicate VOC loading from under the repair shop may be greater than from under the main building.

3.3.2 Wells

One SVE extraction well, five monitoring points and three air inlet wells will be installed. Given that buried utilities are suspected in the test areas, a private utility locating firm will be utilized to clear the investigation area prior to drilling. Anticipated locations are shown on Figure 3-1, although field adjustments to those locations may be made based on the conditions encountered. Figure 3-2 is a schematic diagram of the SVE test system.

The 4-inch diameter PVC extraction well will be advanced to a depth of approximately 7 feet bgs, and will be screened between the depths of 2 and 7 feet bgs. In the event that groundwater is encountered at a shallow depth, the screened interval of the extraction well may be field-adjusted. The extraction well will be connected to the extraction blower via above-ground flexible hose and/or rigid piping. The well-head will include a pressure gauge, a flow meter and an air make-up valve.

Each observation point will consist of 0.75" – 1.5" diameter PVC pipe and a screen installed at the mid-point of the unsaturated thickness (approximately 4-6 ft bgs). In at least one of monitoring locations, three observation points will be installed, screened at depths 2-4 feet, 4-6 feet, and 6-8 feet bgs. The multiple screen depths will facilitate the evaluation of vertical air flow between the surface and the extraction well. Adjustments to these screening depths may be made, based on the depth to the groundwater table encountered at each location. Each observation point will be equipped with a pressure gauge.

Air inlet wells will be 4-inch diameter PVC wells, screened at the same interval as the extraction well. These wells will be equipped with a screw-on plug.

3.3.3 Extraction System

Testing will be conducted using a portable system to extract soil gas and discharge it to the atmosphere. Considering the short duration of the test, vapor treatment will not be performed. Therefore, the system will consist of a blower and a discharge stack equipped with a sampling port.

3.3.4 Test Procedures

Prior to the test, base-line pressure readings will be collected from the extraction well and monitoring wells for the period of 30 minutes at 5-minute intervals. Following that, the extraction blower will be activated, and air will be extracted for the anticipated duration of 7 hours. It is anticipated that three extraction rates (steps) will be used, increasing from the lowest to the highest. Each step will consist of approximately 2 hours. Depending on the results of the test and conditions observed, the number of rate adjustments and the periods between the adjustments may be altered in the field. During the test, the pressure in the extraction well and all monitoring wells will be recorded at 2 min, 5 min, 10 min, 30 min, 60 min, 90 min and 120 min after the beginning of each step. The extraction rate will be recorded at an interval of 10 minutes.

Atmospheric pressure will be monitored throughout the test. During the last hour of the test (6 to 7 hours after commencement of extraction), the three air inlet wells will be opened. If feasible, air flow measurements from each well will be collected at 20-minute intervals using a portable air velocity meter. However, depending on the site conditions (i.e., the proportion of air flow entering the unsaturated zone through the surface to the flow entering through the inlet wells), the flow through the inlet wells may not be measurable.

3.3.5 Air Sample Collection and Analysis

Total VOC concentrations in the discharge stream will be monitored throughout the testing with a properly calibrated photoionization detector (PID). At the conclusion of the testing, one discharge air sample will be collected for analysis of VOCs using USEPA Method TO-15. The sample will be collected over a 30 minute sampling period using a Summa® canister (see SOP, Appendix B-6).

3.4 Soil Sampling

The SVE system will target the source area of the VOC impacts to the soil vapor. During previous investigations, the source area has been identified as being in the southern-to-central part of the site (Figure 2-3) based on the presence of the VOCs in the unsaturated soils. However, the impacts to the unsaturated soils are not fully delineated in the southern and northern limits of the source area. In order to further define the source area and establish the area targeted for SVE, shallow soil sampling at 4 additional locations will be sampled. The locations of the additional delineation samples are shown on Figure 2-3.

Given that buried utilities are suspected in the sampling areas, a private utility locating firm will be utilized to clear the investigation area prior to drilling.

The borings will be advanced with GeoProbe® direct push technologies to the depth of the water table (approximately 7-10 ft bgs). Refer to the SOP in Appendix B-5 for detailed methodology. Continuous soil samples will be collected from each soil boring using a 4 ft macro core sampler with a dedicated, clean acetate liner. The barrel will be advanced the full 4 feet for each push for this application.

Soil in each liner will be screened in the field using a photo ionization detector (PID). Soil samples will be collected from the six-inch interval with the greatest PID readings or visual evidence of contamination (i.e., odors, staining, etc.). If no PID readings are detected or visual evidence of contamination is not observed, sampling will be conducted from the six-inch interval above the water table. One soil sample will be collected from each boring and analyzed for full target compound list (TCL) VOCs plus 10 tentatively identified compounds (TICs) via USEPA SW-846 Method 8260. If the boreholes remain open after sampling, the boreholes will be backfilled with bentonite pellets and/or sand. The concrete floor slab at each boring location will be penetrated using a core drill. Floor penetrations will be repaired with concrete. Exterior pavement penetrations will be repaired with cold-patch asphalt paving.

3.4.1 Field Screening of Soil Samples

Each soil sample will be field screened for VOCs using a photoionization detector (PID) equipped with a 10.6 eV lamp. This type of lamp is capable of ionizing and detecting a broad range of volatile organic compounds. More information regarding the use of the PID for monitoring working conditions and determining the appropriateness of personal protection levels can be found in the Site Specific Health and Safety Plan (HASP). The PID will be calibrated in accordance with the procedures outlined in in Appendix B-4 and the owner's manual, and the battery will be checked for proper voltage at the beginning of each day before use. The calibration result and background readings will be recorded in the field book. If the PID shows erratic readings, additional calibration will be performed. The soil screening will be performed as follows:

1. The acetate liner and enclosed soil will be pierced using a pre-cleaned awl or ice pick at approximately 4 inch intervals.
2. The probe/tip of the PID will be placed in the penetration and "enclosed" with a gloved cupped hand.
3. Conditions will be allowed to stabilize and the reading recorded in the field book.
4. The portion of the soil column registering the highest PID reading above background will be collected for laboratory analysis

3.4.2 Soil Sample Containerization and Shipping

All soil sample handling will be in accordance with the procedures specified in the QAPP (Section 4) and the SOP in Appendix B-2. Soil to be analyzed for VOCs will not be homogenized. The subject soils will be transferred into the sample jar using a laboratory decontaminated plastic trowel or spoon or directly by gloved hand. The sample containers will be placed in a cooler that will be maintained at 4ºC. The samples will be packaged so as to minimize the potential for breakage. All glass jars will be wrapped with protective packaging prior to placement in the cooler for transport. Plastic bags filled with ice and sealed, or blue ice containers will be placed inside each cooler with the samples to ensure that the preservation temperature is maintained. The sample coolers will be transferred, in accordance with the chain of custody procedures, to a courier for next day delivery to the analytical laboratory.

Field QA/QC samples will be obtained and submitted for analysis in accordance with the QAPP.

3.5 Investigation-Derived Waste Management

Investigation-derived waste (IDW) generated from field activities will be managed in accordance with the SOP in Appendix B-1. IDW will be containerized in labeled 55 gallon DOT-approved steel drums and staged in a single location on the Site for characterization and disposal. Information contained on the label will include the drum contents, name, address and telephone number of generator, date(s) the material was placed in the drum, and a BC contact name/telephone number. Wastes will be separated based on type and inventoried. For example, separate drums will be filled for contaminated soil, concrete waste from drilling through the building slab, decontamination wastewater and used personal protective equipment (PPE)/drilling liners.

Available analytical data from environmental media will be correlated with the particular contents of each IDW drum and the disposal subcontractor will prepare associated waste profiles. A table displaying the comparison of analytical data, drum contents and hazardous classification will be provided for use by a waste disposal subcontractor. IDW will be disposed in accordance with applicable Federal, State, and Local regulations.

3.6 Analytical Data Quality Evaluation

All laboratory analytical data will be validated in accordance with the May 2010 DER-10 guidance for preparation of a Data Usability Summary Report (DUSR). DUSRs will be included when data are reported to the DEC.

3.7 Decontamination Procedures

Downhole drilling equipment (e.g., augers, rods, etc.) and test pit excavation equipment (excavator bucket) will be decontaminated before beginning activities at the site, and after completion of each boring, test well or test pit. Decontamination of the equipment will be conducted over a decontamination pad using a high-pressure washer. Rinsate accumulated in the decontamination pad will be pumped into DOT-approved 55-gallon steel drums pending waste characterization and appropriate off site disposal. Decontamination of all equipment other than the downhole drilling equipment will be performed in accordance with the procedures specified in Appendix B-3.

The waste water generated from the decontamination procedures will be containerized and managed as described in Section 3.6.

3.8 Reporting

The results of the PDI will be reported initially to the DEC via monthly progress reports to be submitted on the 15th of each month. Once GE and DEC agree that the objectives of the PDI have been fully achieved, in accordance with GE's BCP application, the results of the PDI will be formally reported in an Alternatives Analysis Report (AAR) and draft Remedial Work Plan (RWP). The AAR/RWP submittal will include the results of the PDI as well as a qualitative human health exposure assessment (HHEA) that will be based on the SC and PDI data. The full scopes of the AAR and RWP are not the subject of this PDI Work Plan. Refer to Section 9 for further PDI reporting details.

Section 4

Quality Assurance Project Plan (QAPP)

The PDI activities will be conducted in accordance with the quality assurance procedures specified in this Quality Assurance Project Plan (QAPP) to ensure that suitable and verifiable sampling and analytical results are obtained. The QAPP includes the items specified in Section 2.4 of DER-10 Technical Guidance for Site Investigation and Remediation (DEC; 2010).

4.1 Project Scope and Goals

The goals and technical approach of the PDI are described in Sections 1.0 and 3.0 of this work plan. The scope of the PDI activities is specified in Section 3.0.

4.2 Project Organization

Key project personnel and subcontractors, including the Project Manager, SVE Design Engineer and Quality Assurance Officer are identified in Section 7.0. Resumes are included in Appendix D.

4.3 Sampling Procedures and Equipment Decontamination

Sampling procedures and equipment decontamination procedures are specified Section 3.0 and in Appendix B-3. The locations of all proposed soil borings are shown on Figure 2-3.

4.4 Analytical Methods and Data Quality Usability Objectives

4.4.1 Analytical Methods

Table 4-1 provides specifications for all environmental media samples and quality control samples, including:

- Matrix type;
- Number of samples to be collected per matrix;
- Number of equipment and trip blanks per matrix;
- Analytical methods to be measured per matrix;
- Number and type of matrix spike and matrix spike duplicate samples to be collected; and
- Number and type of duplicate samples to be collected.

Soil samples will be reported on a dry weight basis. Data will be reported in Category B format along with the required quality assurance data on the required forms and with all raw data including calibration data, blank data, chromatograms, quant reports, sample prep logs, sample run logs and percent moisture work sheets and will be provided in electronic format.

4.4.2 Data Quality Usability Objectives

Implementation of Pre-Design Investigation activities as specified in the PDI focuses on satisfying the following Data Quality Objectives (DQOs):

- Complete delineation of the extent of residual VOC impacts in shallow (unsaturated) soil.
- Test SVE system functionality.

4.5 Field Quality Assurance/Quality Control Samples

Quality control procedures will be followed so that laboratory preparation, sampling, and transport activities do not bias the results of the chemical analysis. Trip blanks and field blanks will be prepared and analyzed as described below to provide a quantitative basis for validating the analytical data. Refer to Table 4-1 for a summary of field QA/QC samples for this project.

4.5.1 Trip Blanks

Trip blanks will not be used in this PDI, as they are prepared only when aqueous sampling is performed, and only when that sampling involves VOC analysis; trip blanks will not be prepared for non-aqueous samples. A trip blank will consist of an analytes-free water sample prepared by the laboratory and will accompany the sample container shipment from the laboratory to the field and back. Trip blanks will be subject only to volatile organic analysis. Trip blanks will be collected at a rate of one per sample shipment or one per two day sampling event, whichever is greater.

4.5.2 Field (Equipment) Blanks

Field blanks, also referred to as equipment blanks, are used to determine if the sampling equipment used in the field might contribute appreciable concentrations of constituents to the samples. Laboratory grade deionized water is run over, or through, the sampling equipment and collected in the same type of sample jars as other samples. Ideally, the results for this analysis will show non-detects for the constituents analyzed. One Field Blank will be collected every day that samples are collected, or one per 20 samples, whichever is greater. Equipment blanks will not be required for SVE exhaust sampling.

4.5.3 Duplicate Samples

Field duplicates are a second aliquot of a field sample. Variations in the sample and duplicate can be indicative of possible inaccuracy or imprecision of laboratory methodologies. One Field Duplicate will be collected for every 20 samples. Duplicate samples will not be required for SVE exhaust sampling.

Field duplicates for soil samples will be collected in one of two ways, depending on the analysis to be performed. For each analyte, with the exception of VOCs, the sample volume will be homogenized in plastic bowls with plastic spoons, or by kneading the material in a plastic bag (e.g., Ziploc© bag). Once homogenized, the material will be evenly distributed into the sample containers. Sample collection materials (bowls, spoons, plastic bags, gloves) will be laboratory decontaminated or single use.

Homogenization of sample material that will be analyzed for VOCs is inappropriate given the volatile nature of these constituents; homogenization would only provide a greater opportunity for constituent loss due to exposure to the atmosphere.

4.5.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples

Additional sample volumes will be collected for MS/MSD analyses to evaluate the effect of the sample matrix on the analytical method. Additional sample volumes for MS/MSD analyses will be collected at a frequency of one pair per sample batch, or at least 1 per 20 samples. The MS/MSD samples will be collected at the same time the primary sample is collected and should be collected from a sample location that contains concentrations of the constituent of concern. MS/MSD samples will not be required for SVE exhaust sampling.

4.6 Sample Handling Requirements

4.6.1 Sample Containers and Preservatives

The appropriate sample containers and associated preservatives must be obtained following the applicable NYSDEC and USEPA guidance. The containers and preservatives will be supplied by the laboratory that will conduct the analyses. It is crucial that the sample containers be carefully organized and inventoried prior to the initiation of the sampling program in order to provide sufficient time to rectify problems, should they occur. Finally, pre printed sample labels will be placed on the sample containers.

The various required preservation methods, container types, and maximum sample holding times are listed on Table 4-2.

4.6.2 Sample Labels and Nomenclature

Sample labels are required on sample containers for the primary purpose of sample identification. Specific field data need not be recorded on the labels, since such information will be recorded on field data sheets. The sample labels will contain the following information:

- Sample ID Number
- Location identification number (i.e., well number, boring designation)
- Analysis to be performed
- Preservative (optional)
- Project name and number
- Date and time of sample collection
- Initials of sampler

The method of identification of a sample depends on the type of measurement or analysis performed. When field screening measurements (e.g., pH, dissolved oxygen, or turbidity) are made, data are recorded directly in logbooks or on field investigation forms. Identifying information such as project name, station number, station location, date and time, name of sampler, field observations, remarks, or other pertinent information will be recorded.

Samples collected for laboratory analysis during the field investigation will be specifically designated for unique identification. Each sample will be designated by an alpha-numeric code which will identify the sampling location, type or as necessary depth.

Aqueous and solid samples collected as a part of the work will be assigned unique sample identifiers. The sample identifiers are required in order to identify and track each of the samples collected for analysis. Associated field QA/QC samples such as duplicates and field blanks will be further identified adding the date of collection to the sample name as shown below, and as needed a number will be added sequentially to distinguish the samples.

Each of the samples will be identified by a unique alpha numeric code that indicates the particular sample type, location, and date. The format of the code is as follows: Site Name, Medium/Sample Type Code, Location Number

The three codes that make up the sample identifier are described as follows:

1. The Site name –BS (GE Bay Shore Site);
2. The medium/sample type codes listed below:
    a. SB – Soil Boring sample
    b. SVE – Soil Vapor Extraction exhaust sample

   c. FB – Field Blank sample
   d. EB – Equipment Blank sample
   e. DUP – Duplicate sample
   f. MS/MSD – Matrix Spike/Matrix Spike Duplicate sample
3. The location code will be keyed to the specific sample designation.

The following is an example of a sample identifier that will be used for soil samples collected for laboratory analysis:

BS-SB-14-3.5-4: Indicating that the soil sample was collected from soil boring location SB-14 from a depth of 3.5 to 4 feet below ground surface.

4.6.3 Field Sample Storage

Sample containers will be held on site for a period not exceeding two (2) calendar days. Sample shipments to the laboratory will be by overnight courier. When practicable, the sample containers will arrive back at the laboratory within four (4) days of their initial shipment to the field.

4.6.4 Sample Shipment

Shipment of samples to an analytical laboratory is usually required upon completion of sample collection. Proper packaging is necessary in order to protect the sample containers, to maintain the samples at a temperature of 4±2°C, and to comply with applicable transportation regulations.

In general, samples are shipped using packaging that is supplied by the analytical laboratory. The packaging normally includes a shippable insulated box such as an ice cooler and contains protective internal packaging materials such as foam sleeves. Some laboratories use proprietary sample packaging with integral internal packaging. In either case, provisions need to be made for maintaining the temperature of the samples with the use of re freezable ice packs or sealed bags of ice.

Regulations must be observed regarding the shipment of Dangerous Goods. Sample containers and certain field equipment may be defined as Dangerous Goods such that special requirements must be followed for their shipment. Air shipment of Dangerous Goods is regulated by the International Air Transport Association (IATA) as described in “Dangerous Goods Regulations” (IATA, current year). IATA Regulations are updated annually. Shipment by ground is regulated by the U.S. Department of Transportation (DOT; 49 CFR). Furthermore, individual shippers (e.g., Federal Express) or other countries (international shipments) may have additional requirements for dangerous goods shipment.

Environmental samples, (e.g., groundwater, surface water, or soil samples) containing relatively low concentrations of contaminants, (regulated under 40 CFR) are currently exempt from Hazardous Goods regulations. 40 CFR 261.40(d) states, “A sample of solid waste or a sample of water, soil, or air which is collected for the sole purpose of testing to determine its characteristics or composition is not subject to this Part or Parts 262 through 267 or Part 124 of this chapter or to the notification requirements of Section 3010 of RCRA”. Sample containers must be properly packed such that inadvertent spillage does not occur during shipment.

Environmental samples which are known or suspected to be toxic, corrosive, flammable, or those which emit a noxious odor or create an anesthetic annoyance or discomfort to passengers and/or flight crews when shipped by air, must be packed, labeled, and shipped in accordance with current IATA regulations. Refer to “Dangerous Good Regulations” (current year), Section 3-Classification.

Specific regulations exist (Shipment in Excepted Quantities) for the shipment of many reagents that are commonly used as preservatives and decontamination agents. Consequently, the shipment to the field site of “empty” sample containers containing small quantities of preservatives must be conducted in accordance with the regulations. The most significant limitations for the shipment of preservatives (IATA, current year) involve those for nitric acid in which only small quantities (<0.5L) of low concentration (<20 percent) nitric acid can be shipped in a given sample shipment.

4.6.5 Chain of Custody

Chain of custody procedures are designed to trace the sample from the time that it is collected until it, or its derived data, are used. Samples would be considered to be "in custody" under the following conditions:

- It is in personal possession.
- It is in personal view after being in personal possession.
- It was in personal possession when it was properly secured.
- It is in a designated secure area.

A chain of custody form (to be supplied by the specific laboratory providing service) is to be initiated at the time that the sample containers leave the site at which they are prepared, usually that of the analytical laboratory supplying the containers. It is important that the field personnel completely fill out the applicable sections of the form. The chain of custody forms will be placed in shipping containers, protected from moisture using plastic bags (e.g., Ziploc®) and will accompany the containers during shipment to the laboratory. The field personnel collecting the samples will be responsible for the custody of the samples until transportation to the laboratory. Sample transfer requires the individuals relinquishing and receiving the samples to sign, date, and note the time of transfer on the chain of custody forms. The chain of custody is considered to be complete after it has been received and signed in by the analytical laboratory. A copy of the chain of custody record will be maintained by the field personnel along with the other field records.

Common carriers (e.g., Federal Express) are not expected to sign the chain of custody form. However, the bill of lading or airbill becomes part of the chain of custody record when a common carrier is used to transport the samples.

4.7 Analytical Laboratory QA/QC

The analytical laboratory shall have systems and procedures to ensure and document that the data provided meets the requirements for precision, accuracy, representativeness, completeness, and comparability.

4.7.1 Quality Assurance Management Plan

The laboratory shall submit a current, controlled, and signed copy of the Quality Assurance Management Plan. The Plan shall be in general accordance with the requirements set forth in the draft National Environmental Laboratory Accreditation Program guidelines (Federal Register, December 2, 1994). These include:

All laboratories shall prepare and have available for review a written description of the laboratory's quality assurance activities, i.e., a QA plan. The QA plan must be an independent document that may incorporate by reference, already available standard operating procedures (SOPs) or other material, e.g., methods, guidance documents, etc., that are approved by the laboratory management. Analysts in the laboratory should either have copies of the document or easy access to the document. The items listed below constitute essential requirements of a Quality System. All laboratories should be encouraged to add any additional items thought to improve the analytical data. The following items shall be included:

- General QC procedures
- Performance evaluation samples
- Staff

- Equipment
- Test methods and standard operating procedures (SOPs)
- Physical facilities
- Sample acceptance policy and sample receipt
- Sample tracking
- Record keeping, data review and reporting
- Corrective action policy and procedures
- Definition of terms
- Bibliography

Substantive changes, modifications, or revisions to the document shall be provided within fifteen (15) days of implementation.

4.7.2 Standard Operating Procedures

The laboratory shall maintain for all procedures written, practical, standard operating procedures (SOPs). The laboratory's Quality Assurance Manager shall maintain the SOPs and a current copy must be available at the location where the analysis is performed.

The laboratory SOP must provide directions for the step-by-step execution of all analyses and tasks performed by the laboratory. The SOP must reference the source of the procedure (US EPA Method, ASTM, Standard Methods, etc.). The SOP must:

- Be uniquely identified as to version or revision.
- Be consistent with the instrument manufacturer specifications and instructions.
- Be available for auditing purposes.
- Be reviewed and updated to reflect the current practices and facility requirements.
- Be archived for future reference in usability reviews and evidentiary situations.
- Be subject to procedures which prevent the use of outdated versions.

4.7.3 Quality Assurance Measurements

The laboratory must perform all applicable quality assurance measurements indicated in the cited procedure. At a minimum, each sample preparation and analysis batch must include a method blank, a blank spike (or laboratory control standard), a matrix spike, and a duplicate (or matrix spike duplicate for organic analyses). The method blank and LCS results shall be reported in the same units as the client samples. A batch will be defined as no more than twenty samples (excluding QC samples) of a similar matrix, prepared and/or analyzed together.

4.7.3.1 Precision and Accuracy

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Total precision is the measurement of the variability associated with the entire sampling process. It is determined by analysis of duplicate or replicate field samples and measures variability introduced by both the laboratory and field operations. Duplicate samples and matrix duplicate spiked samples are analyzed where applicable, to assess field and analytical precision, and the precision measurement is determined using the relative percent difference (RPD) between the duplicate results.

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It therefore reflects the total error associated with the measurement. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into a Laboratory Control Sample (LCS), also known as a blank spike. For some organic compounds, surrogate recoveries can also be used to assess accuracy and method performance for each sample analyzed.

Accuracy of matrix spike recoveries is used to evaluate matrix effects in individual samples for a specific site. Matrix spike data is not used as the primary accuracy determination for laboratory QC purposes. Specific methods do have very wide "recommended" limits for controlling laboratory data.

Statistical Determination of Precision and Accuracy

Accuracy is evaluated by analyzing matrix spike data. For measurements where matrix spikes are used, the percent recovery will be calculated as follows:

$$\%R = 100\% \times \left[\frac{S-U}{C_{sa}}\right]$$

Where: %R = percent recovery

S = measured concentration in spiked aliquot

U = measured concentration in unspiked aliquot

Csa = actual concentration of spike added.

When a standard reference material (SRM) is used:

$$\%R = 100\% \times \left[\frac{C_m}{C_{srm}}\right]$$

Where: %R = percent recovery

Cm = measured concentration of SRM

Csrm = actual concentration of SRM

If calculated from duplicate measurements, relative percent difference (RPD) is the normal measure of precision as defined by the following equation:

$$RPD = \frac{(C_1 - C_2) x100\%}{\frac{(C_1 + C_2)}{2}}$$

Where: RPD = relative percent difference

C1 = larger of the two observed values

C2 = smaller of the two observed values

If calculated from three or more replicates, the relative standard deviation (RSD) will be used rather than RPD in accordance with the following equation:

$$RSD = (s / \bar{y}) \times 100\%$$

Where: RSD = relative standard deviation

s = standard deviation

$\bar{y}$ = mean of replicate analyses

Standard deviation is defined as follows:

$$S = \sqrt{\frac{\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2}{n-1}}$$

Where: s = standard deviation

Y_i = measured value of the *i* th replicate

$\bar{y}$ = mean of replicate measurements

n = number of replicates

The method detection limit is the laboratory established smallest amount of analyte that can be measured and reported with 99% confidence that the concentration is greater than zero.

MDL is defined as follows for all measurements:

MDL = $t_{(n-1,\ 1-a\ =\ 0.99)}\ (S)$

Where: MDL = method detection limit

S = standard deviation of the replicate analyses

$t_{(n-1,\ 1-a\ =\ 0.99)}$ = student's t-value for a one sided 99 percent confidence level and a standard deviation estimate with n 1 degrees of freedom

The precision and accuracy of each measured parameter shall be within the guidelines set forth in the published method. LCS recovery acceptance criteria shall be based on control charts and must include the last twenty (20) measurements. In the absence of 20 measurements, the default acceptance criteria may be no greater than 75-125%. Matrix spike and surrogate recovery criteria must be established in accordance with the published method.

Corrective action for LCS, surrogate, and matrix spike failures must be specified in the Laboratory Quality Assurance Manual or in the Laboratory SOP for the given method. Discussion of the application of the corrective action shall be provided in the analysis case narrative.

4.7.3.2 Representativeness

Samples collected in the filed shall be representative of the conditions that are being measured. The lab will take steps to ensure that subsamples of the samples submitted are representative of the container as a whole.

4.7.3.3 Comparability

All measurements made by the laboratory must be comparable to applicable reference standards. The lab must participate in interlaboratory comparisons as necessary to maintain the state certifications. The lab must provide copies of results of performance in interlaboratory programs upon request.

4.7.3.4 Completeness

Completeness is defined as the number of analyses considered to be valid compared to the number of analyses that were considered necessary for accomplishing the task. Typically, studies are designed with extra sampling so that the loss of a few samples (perhaps 10 percent) would still leave enough data to achieve the desired objectives. For the purpose of estimating completeness, the total number of analyses required for accomplishing the objectives requiring analytical laboratory data is 90 percent of the non QC samples submitted for analysis.

All samples submitted to the lab and all analyses requested will be intended to fulfill project requirements. Results submitted which are not in compliance with method requirements or quality assurance measurements may be rejected.

4.7.4 Sample Management

Samples shall be checked upon receipt for thermal preservation (if applicable). The results of the check shall be recorded on the chain-of-custody submitted with the samples. Chemical preservation (e.g., appropriate pH) shall be checked upon receipt or prior to sample preparation/analyses. The results of such checks shall be recorded. Data from any samples that do not meet the criteria must be discussed in the report case narrative.

The samples shall be properly preserved and stored in approved containers specified by the laboratory quality assurance program and the applicable methods. Where samples must be split in the laboratory, the laboratory will perform the required tasks in a manner that insures that all subsamples are representative of the original sample. Samples shall be stored in a secure area.

The laboratory shall assign a unique identification (ID) code to each sample received in the laboratory. The laboratory shall design a system to unequivocally identify all samples, subsamples and subsequent extracts and/or digestates so that each aliquot is uniquely identified. This laboratory code shall maintain an unequivocal link with the unique field ID assigned each container. The laboratory ID number shall be placed on the sample container as a durable label. The laboratory ID number shall be entered into the laboratory records and shall be the link that associates the sample with related laboratory activities (i.e., sample preparation, calibration, etc.).

4.8 Laboratory Reporting

Laboratory analytical reports shall consist of three deliverables:

- Summary Data Report
- Raw Data Validation Package
- Electronic Data Deliverable (EDD)

The Summary Data report will consist of the following information:

- Cover letter - a statement signed by both the responsible corporate individual and the Project Manager indicating that the report meets the technical specifications and applicable requirements of the contract.
- Case narrative - A brief statement of the condition of sample receipt, compliance with holding times, a discussion of conditions encountered, organized by analytical procedures performed, which will affect the interpretation of results. If any quality assurance measurements did not meet the specifications of the procedure, the narrative will indicate why the data is reportable.
- Cross reference of Sample Identification with laboratory identification.
- Sample Results - The results of the analysis shall include the sample preparation and analytical methods, dates of sample preparation and analysis, method detection limit or reporting limit, concentration of analyte, units of concentration, sample matrix.
- Blank results.
- Blank spike or Laboratory Control Standard results. (Analyte, amount spiked, amount recovered, percent recovery, acceptance criteria.)
- Surrogate analysis results.
- Matrix spike/duplicate matrix spike results.

The Raw Data Validation Package report will consist of the following information (as applicable):

- Initial calibration data (including raw data, chromatograms, instrument response data, standard preparation logs, standard source records).
- Instrument performance checks (continuing calibration verification, blank verification, etc.).
- Internal standard measurements.
- Quantitation reports.
- Mass spectra for each reported analyte.
- Copies of sample preparation worksheets, bench worksheets, run logs, cleanup procedure checks (GPS, florisil, etc.).
- Standard addition results, serial dilution results.
- Applicable Method Detection Limit (MDL) study results and dates of MDL studies.

A relational database (Environmental Quality Information System [EQuIS]) will be utilized to provide data entry, secure storage, access, and evaluation capabilities of data obtained as part of the PDI. Laboratory data collected will be obtained as electronic data deliverables (EDDs) in the EQuIS 4-File Format.

4.9 Data Documentation and Management

4.9.1 Field Notebook

A field note book will be dedicated to the GE Bay Shore PDI project. All note books and any original forms will become part of the permanent project file. The following daily information will be recorded in the field notebook:

- Date;
- Weather conditions;
- Personnel;
- All site visitors;
- Chronological, general description of all field activities that day;
- Records of all field measurements;
- Descriptions of any modifications to the PDI Work Plan;
- Record of equipment calibration; and
- Sample collection data.

4.9.2 Laboratory Records

The laboratory shall implement protocols that will produce unequivocal, accurate records which document all laboratory activities associated with sample receipt, preparation, analysis, review and reporting. These records will be held a minimum of 7 years.

The activities documented shall include but are not limited to:

- Sample preservation including appropriate sample container and compliance with holding time;
- Sample identification, receipt, acceptance or rejection and log-in;
- Sample storage and tracking (includes shipping receipts, transmittal forms, and internal routing and assignment records);
- Sample preparation (includes cleanup and separation protocols, ID #s, volumes, weights, instrument printouts, meter readings, calculations, reagents, etc.);
- Sample analysis;
- Standard and reagent origin, receipt, preparation, and use;
- Equipment receipt, use, specification, operating conditions and preventative maintenance;
- Calibration criteria, frequency and acceptance criteria;

- Data and statistical calculations, review, confirmation, interpretation, assessment and reporting conventions;
- Method performance criteria including expected quality control requirements;
- Quality control protocols and assessment;
- Electronic data security, software documentation and verification, software and hardware audits, backups, and records of any changes to automated data entries;
- All automated sample handling systems;
- Records storage and retention; and
- Sample disposal including the date of sample or subsample disposal and name of the responsible person.

In addition to documenting all the above-mentioned activities, the following shall be retained:

- All original raw data, whether hard copy or electronic, for calibrations, samples and quality control measures, including analysts work sheets and data output records (chromatograms, strip charts, and other instrument response readout records);
- Copies of final reports;
- Archived standard operating procedures;
- Correspondence relating to laboratory activities for a specific project;
- All corrective action reports, audits and audit responses;
- Performance evaluation results and raw data; and
- Data review and cross checking.

4.9.3 Project Database

A relational database (EQuIS) will be utilized to provide data entry, secure storage, access, and evaluation capabilities of data obtained as part of the PDI. Laboratory data collected will be obtained as electronic data deliverables (EDDs) in a specific format (EQuIS 4-File Format) provided to the laboratory. The EDDs will be imported directly into the database and will be checked against conventional laboratory reports. In addition, survey coordinate data and certain sample descriptive data will also be incorporated into the database. The database will reside on a secure computer server and will utilize Microsoft SQL Server® software with a web user interface. Queries from the database will provide data output used in the preparation of data tables and graphs. In addition, the database is fully integrated with the geographic information system (GIS). Full laboratory data deliverable packages will also be obtained in electronic form in indexed portable document format (PDF) files.

4.9.4 Project Data Reduction

Following receipt of the laboratory reports by BC, the results will be compiled in the EQuIS database for the project. Queries will be used to extract relevant results for tabular reporting. Additional information on project reporting requirements is provided in Section 9.

4.10 Field Instrumentation

All field analytical instrumentation will be calibrated and maintained per the following chart:

Field Analytical Instrument Maintenance and Calibration Protocols

Equipment	Calibration	Frequency
Temperature	Check against a mercury thermometer	Start and end of each day
Rechargeable equipment batteries	Charge	After use as required
Photoionization Detector (PID)	Calibrate per manufacturer's specification with appropriate gas.	Start of each day being used.
Air Pressure Meter	Calibration according to manufacturer's recommendations with ambient air	At the beginning of each day

Section 5

Health and Safety Protocols

5.1 Health and Safety Plan

All field activities will be performed in accordance with the site-specific Health and Safety Plan (HASP) included in Appendix A. The HASP has been prepared in accordance with the standards set by the Occupational Safety and Health Administration (OSHA) as stated in Title 29 of the Code of Federal Regulations (29 CFR) with emphasis on the following subsections, as well as other applicable federal, state, and local laws, regulations, and statutes:

1)	1910.120	Hazardous Waste Operations and Emergency Response
2)	1910.1000	Toxic and Hazardous Air Contaminants
3)	1910.1200	Hazard Communication, Employee Right-to-Know Law
4)	1904	Recording and Reporting Occupational Injuries and Illnesses
5)	1990	Identification and Regulation of Potential Occupational Carcinogens
6)	1926	Safety and Health Regulations for Construction

5.2 Community Air Monitoring Plan

Community air monitoring will be performed during PDI field activities in accordance with the New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan, included in Appendix C. Air monitoring readings will be recorded in a logbook and will be available for review by the NYSDEC and NYSDOH. Real time air monitoring will be conducted during work activities for VOCs and particulates (i.e., dust) at the downwind perimeter of each designated work area. Air monitoring will be performed and recorded at up to 15 minute intervals.

The Community Air Monitoring Plan (CAMP) is not intended for use in establishing action levels for worker respiratory protection.

CAMP VOC Action Levels

The following action levels for VOCs are in accordance with the New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan:

VOC Action Level	Response
Below 5 ppm above background for the 15-minute average	Continue and/or resume work activities
> 5 ppm above background for the 15-minute average	Temporarily halt work and continue monitoring
5 to < 25 ppm	Work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions and continue monitoring
> 25 ppm	Cease operations. Contact PM and BC Director of Health and Safety or designee immediately.

CAMP Particulate Action Levels

The following action levels for particulates less than 10 micrometers in size (PM-10) are in accordance with the New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan:

Particulate Action Level	Response
> 0.1 mg/m^3 above background for the 15-minute average or if airborne dust is observed leaving the work area	Employ dust suppression techniques
0.1 to 0.15 mg/m^3	Work may continue with dust suppression techniques provided downwind PM-10 particulate levels do not exceed 0.15 mg/m^3 above background for the 15-minute average and airborne dust is not observed leaving the work area
> 0.15 mg/m^3 with dust suppression techniques implemented	Cease operations. Contact PM and BC Director of Health and Safety or designee immediately.

Section 6

Citizen Participation Activities

A citizen participation plan (CPP) was prepared and submitted to the DEC by GE. The CPP provides summary information about the type of contamination that has been identified; an overview of the planned investigation and remediation; opportunities for public participation; primary contact information for various State, local and private agencies; and information on where project-related documents are available.

During the remediation process, GE and the DEC will keep the public informed of planned or ongoing actions; environmental conditions; public health threats (if any) posed by contamination and responses under consideration; and project status. GE and the DEC will also provide opportunities for the public to give information, opinions and perspectives on technical decisions about the site.

Section 7

Project Management

The management approach and identification of key project personnel and subcontractors for the execution of the PDI are detailed in the following sections. Regular updates on progress will be provided to the DEC. Any significant variations from the PDI Work Plan will be reported and discussed accordingly. A summary of the roles, responsibilities and contact information for each individual appears below. Resumes are provided in Appendix D.

7.1 Primary Contractor

The environmental consultant assigned to the PDI activities is Brown and Caldwell Associates (BC), a wholly owned subsidiary of Brown and Caldwell. BC is licensed to provide professional engineering services in New York State. BC will execute and report the results of the PDI. The PDI will be conducted in accordance with the Brownfield Cleanup Agreement between GE and the DEC, dated December 31, 2013 (Index C152204-11-13), and applicable regulations.

Michael Miner, PE will serve as project manager for the remedial activities.

Frank Williams, PG will serve as the technical lead for the PDI and be responsible for overall management and communication with GE and the DEC.

Mare Ostrowski, PE will serve as the design engineer for the SVE system.

Responsibility for maintaining QA/QC during the PDI lies with the project manager and the QA Officer, Greg Cole. Mr. Cole will be responsible for validating all supplemental SC analytical data and preparing a Date Usability Summary Report (DUSR),

7.2 Subcontractors

Other contractors will be retained to provide various services under subcontract to BC, as described below:

Direct-Push Drilling Services: The drilling subcontractor will be Zebra Environmental. It will be responsible for acquiring drilling permits, UFPO utility clearances, and supplying services (including labor, equipment, and materials) required to perform the drilling activities, including soil borings and SVE test well installation and development. It will also be responsible for the maintenance and quality control of the equipment needed to perform those activities. The drilling subcontractor will be responsible for containerizing and transporting investigation-derived waste (IDW) to the temporary staging area on the Site. The drilling subcontractor will also be responsible for following equipment decontamination procedures. Upon completion of the work, the drilling subcontractor will be responsible for decontaminating all equipment prior to demobilizing from the Site.

Analytical Laboratory: The analytical laboratory subcontractor will be TestAmerica Buffalo, which provided the analytical services for the previous SC investigation. It will provide analytical services for air and solid media, and will be responsible for providing Summa® canisters, sample bottles and preservatives (as necessary) and providing laboratory analysis and appropriate data reporting TestAmerica Buffalo is a DOH ELAP certified laboratory.

Surveying Services (TBD): The survey subcontractor will be licensed in New York. The surveyor will be responsible for providing land survey data as required, including the horizontal coordinates and vertical elevations of the ground surface for soil sample locations, SVE test locations, and other locations as directed by BC.

Section 8

Schedule

As noted in GE's application to the BCP, the estimated duration of the PDI is approximately 10 weeks (see table below). Assuming DEC approval of the PDI Work Plan is received by February 14, 2014, PDI field activities should be completed by approximately April 28, 2014.

Task		Estimated Duration	Estimated Completion
1.	Develop and submit PDI Work Plan		January 31, 2014
	Agency Review and Revisions	2 weeks	February 14, 2014
2.	Conduct Pre-Design Investigation	10 weeks	April 28, 2014
3.	Prepare and submit Alternatives Analysis Report (AAR) and draft Remedial Work Plan (RWP)	10 weeks	TBD
	Agency Review and Revision	4 weeks	TBD
4.	Prepare and submit Remedial Design documents	10 weeks	TBD
	Agency Review and Revision	4 weeks	TBD
5.	Construction and startup of SVE/SSD Systems	12 weeks	TBD
	Total	52 weeks	

Section 9

Reporting

As noted in Section 3.9, the results of the PDI will be reported initially to the DEC via monthly progress reports to be submitted on the 15th of each month. Once GE and DEC agree that the objectives of the PDI have been fully achieved, in accordance with GE's BCP application, the results of the PDI will be formally reported in an Alternatives Analysis Report (AAR) and draft Remedial Work Plan (RWP). The AAR/RWP submittal will include the results of the PDI as well as a qualitative human health exposure assessment based on the SC and PDI data. The scopes of the AAR and RWP are not the subject of this PDI Work Plan.

Results of the soil sampling will be discussed in the AAR/RWP report. Appendices will be included to present the boring logs and analytical data. Analytical data will be summarized in a table, and combined with results of previous investigations on a figure delineating the extent of the source zone.

SVE test results will be reported as follows:

- Tables presenting measurements of atmospheric pressure, pressure at all gauges, as well as the soil vapor extraction rates, both prior to and throughout the test.
- Figures showing the pressure distribution (extraction and monitoring wells/points) at the end of each period where relatively constant extraction rate was maintained.
- Tables presenting analytical data from the air samples collected throughout the test.
- Results of flow measurements conducted within the air inlet wells.

Section 10

References

Brown and Caldwell Associates, 2012. Site Characterization Report, Former Baron Blakeslee Site, Bay Shore, New York. January 2012.

Brown and Caldwell Associates, 2013. Site Characterization Report Addendum, Former Baron Blakeslee Site, Bay Shore, New York. April 2013.

New York Sate Department of Environmental Conservation, 2010. DER-10 Technical Guidance for Site Investigation and Remediation. NYSDEC Division of Environmental Remediation. May 3, 2010.

New York State Department of Health, 2006. Guidance for Evaluating Soil Vapor Intrusion in New York State. October 2006.

Tables

TABLE 4-1
SUMMARY OF LABORATORY ANALYSES
PRE-DESIGN INVESTIGATION
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

Laboratory Analysis	Soil (SB-13 through SB-16) TCL VOCs Method 8260	SVE Exhaust (SVE-1 through SVE-3) VOCs Method TO-15
Total Environmental Media Samples	4	1
Duplicates	1	0
MS/MSD	1	0
Trip Blanks	0	0
Equipment Blanks	1	0
Total QA/QC Samples	3	0
Total Samples	7	1

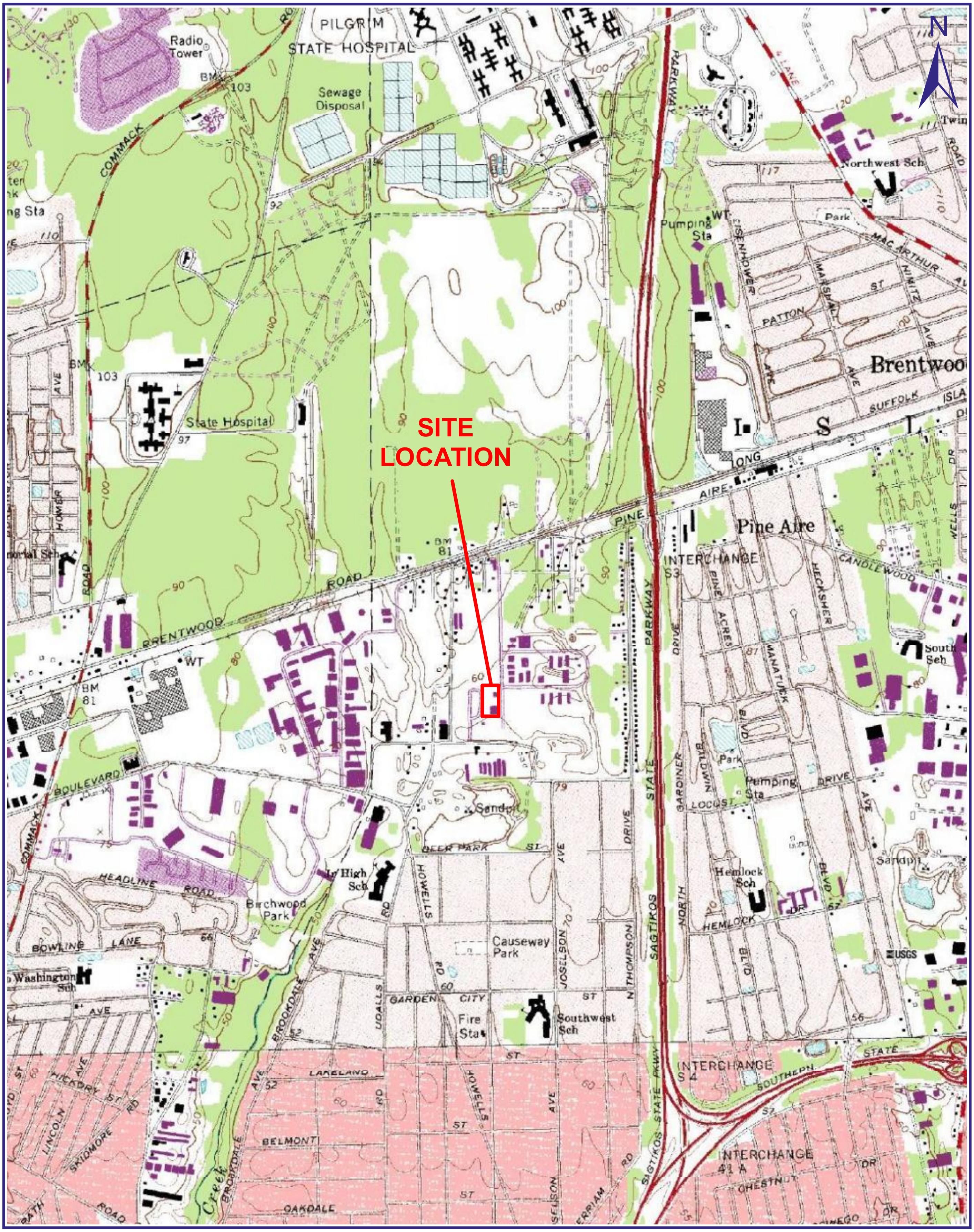
TABLE 4-2
SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIMES
PRE-DESIGN INVESTIGATION
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

Analytical Parameter	Matrix	Typical Volume Required[a]	Container	Preservative	Maximum Holding Time
Volatile Organic Compounds (VOCs)	Soil	80 mL	Two 40-mL sealed zero headspace containers (VOA vials)	Cool to 4±2°C	7 days
Volatile Organic Compounds (VOCs)	SVE Exhaust	6 liters	Summa® Canister	None	30 Days

a. Analytical laboratory should be consulted for specific volume requirements.

Figures

1/22/2014



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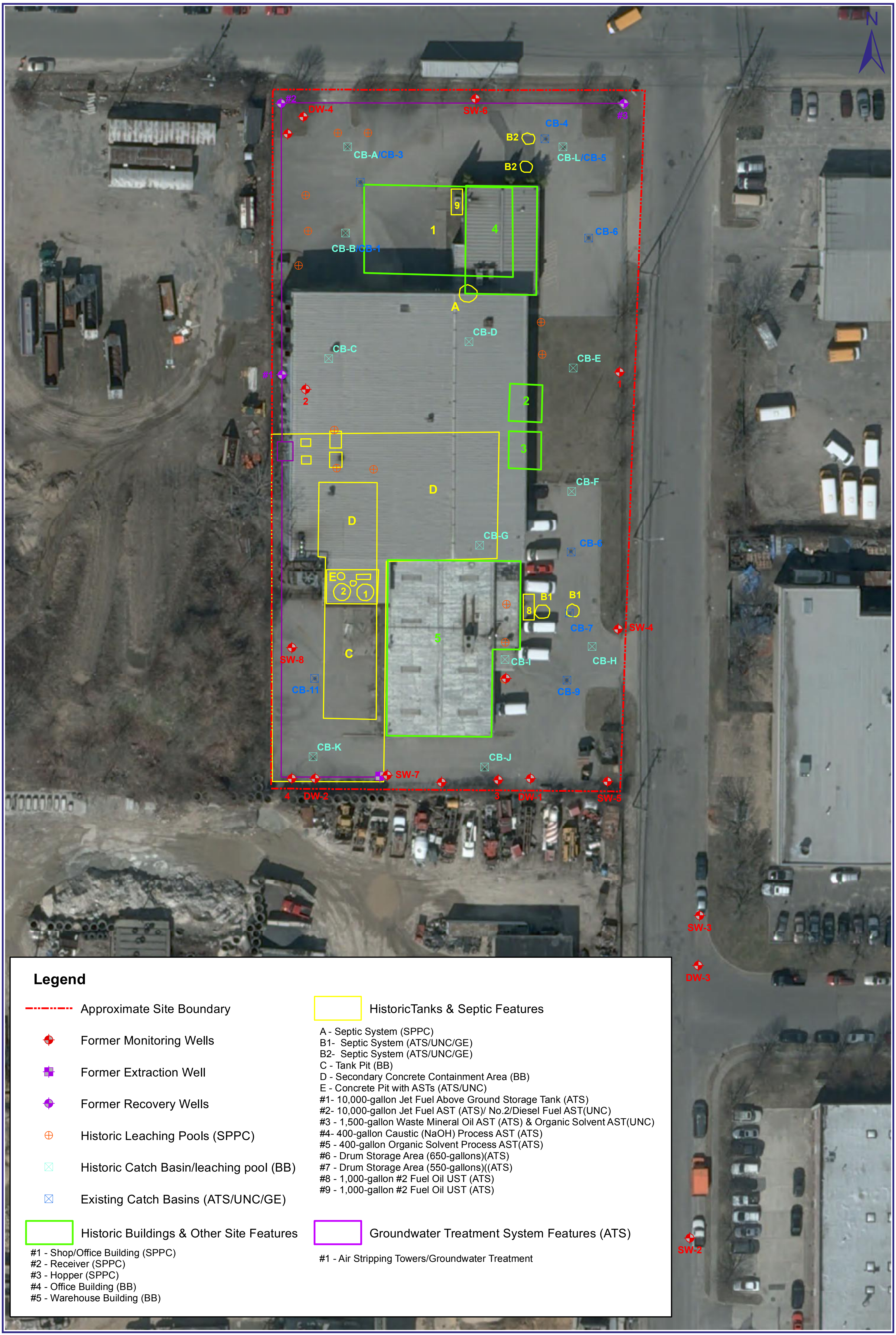
Brown AND Caldwell

FIGURE 2-1
SITE LOCATION
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

Source: USGS Topographic Quadrangles
Greenlawn abd Bay Shore West Quads

0 1,000 2,000
Feet

1/22/2014



Legend

-·-·- Approximate Site Boundary

⊕ Former Monitoring Wells

■ Former Extraction Well

● Former Recovery Wells

⊕ Historic Leaching Pools (SPPC)

☒ Historic Catch Basin/leaching pool (BB)

☒ Existing Catch Basins (ATS/UNC/GE)

🟩 Historic Buildings & Other Site Features

- #1 - Shop/Office Building (SPPC)
- #2 - Receiver (SPPC)
- #3 - Hopper (SPPC)
- #4 - Office Building (BB)
- #5 - Warehouse Building (BB)

🟨 HistoricTanks & Septic Features

- A - Septic System (SPPC)
- B1- Septic System (ATS/UNC/GE)
- B2- Septic System (ATS/UNC/GE)
- C - Tank Pit (BB)
- D - Secondary Concrete Containment Area (BB)
- E - Concrete Pit with ASTs (ATS/UNC)
- #1- 10,000-gallon Jet Fuel Above Ground Storage Tank (ATS)
- #2- 10,000-gallon Jet Fuel AST (ATS)/ No.2/Diesel Fuel AST(UNC)
- #3 - 1,500-gallon Waste Mineral Oil AST (ATS) & Organic Solvent AST(UNC)
- #4- 400-gallon Caustic (NaOH) Process AST (ATS)
- #5 - 400-gallon Organic Solvent Process AST(ATS)
- #6 - Drum Storage Area (650-gallons)(ATS)
- #7 - Drum Storage Area (550-gallons)((ATS)
- #8 - 1,000-gallon #2 Fuel Oil UST (ATS)
- #9 - 1,000-gallon #2 Fuel Oil UST (ATS)

🟪 Groundwater Treatment System Features (ATS)

- #1 - Air Stripping Towers/Groundwater Treatment

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FIGURE 2-2
SITE PLAN
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

0 25 50
Feet

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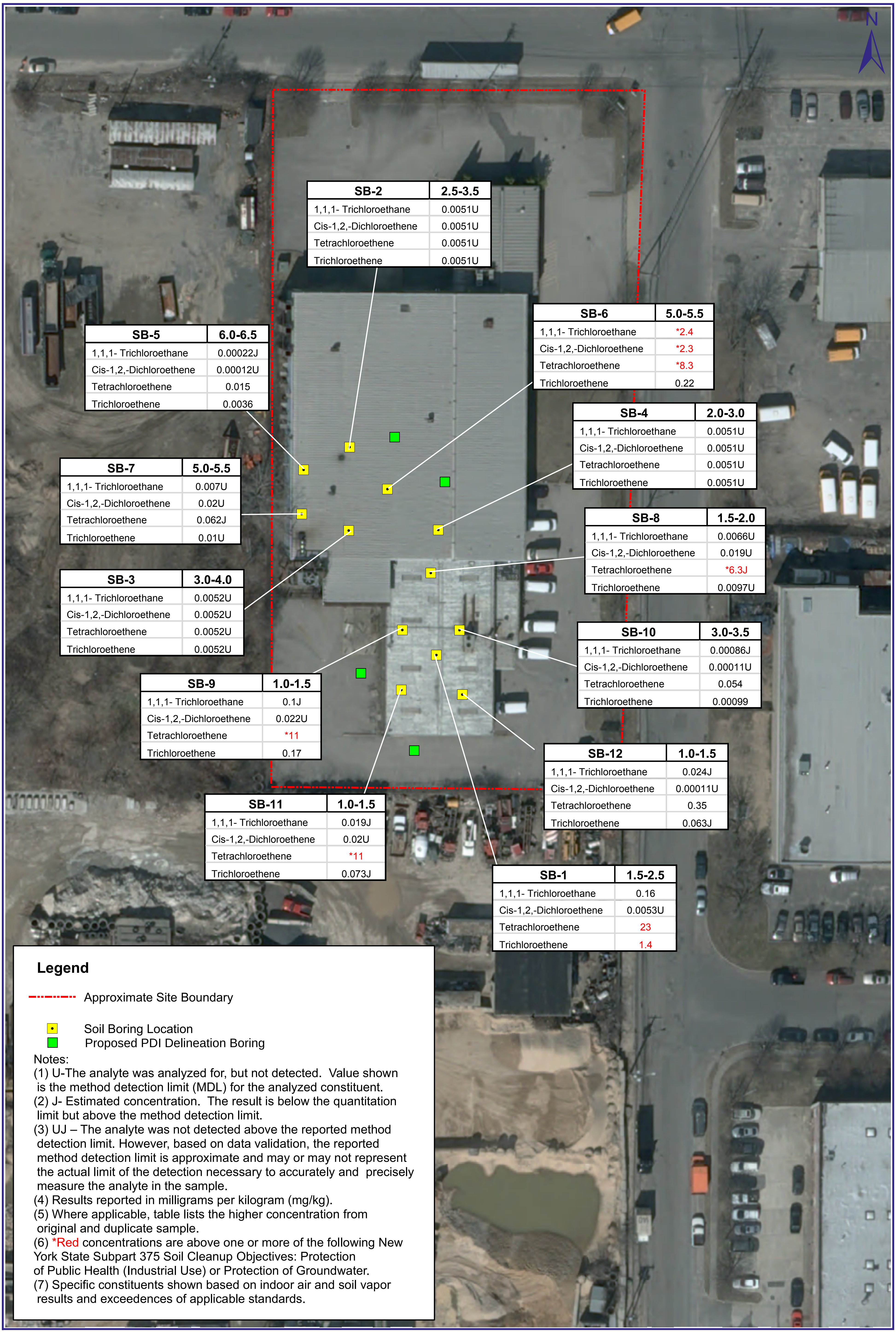
1/22/2014



SB-2	2.5-3.5
1,1,1- Trichloroethane	0.0051U
Cis-1,2,-Dichloroethene	0.0051U
Tetrachloroethene	0.0051U
Trichloroethene	0.0051U

SB-6	5.0-5.5
1,1,1- Trichloroethane	*2.4
Cis-1,2,-Dichloroethene	*2.3
Tetrachloroethene	*8.3
Trichloroethene	0.22

SB-5	6.0-6.5
1,1,1- Trichloroethane	0.00022J
Cis-1,2,-Dichloroethene	0.00012U
Tetrachloroethene	0.015
Trichloroethene	0.0036

SB-4	2.0-3.0
1,1,1- Trichloroethane	0.0051U
Cis-1,2,-Dichloroethene	0.0051U
Tetrachloroethene	0.0051U
Trichloroethene	0.0051U

SB-7	5.0-5.5
1,1,1- Trichloroethane	0.007U
Cis-1,2,-Dichloroethene	0.02U
Tetrachloroethene	0.062J
Trichloroethene	0.01U

SB-8	1.5-2.0
1,1,1- Trichloroethane	0.0066U
Cis-1,2,-Dichloroethene	0.019U
Tetrachloroethene	*6.3J
Trichloroethene	0.0097U

SB-3	3.0-4.0
1,1,1- Trichloroethane	0.0052U
Cis-1,2,-Dichloroethene	0.0052U
Tetrachloroethene	0.0052U
Trichloroethene	0.0052U

SB-10	3.0-3.5
1,1,1- Trichloroethane	0.00086J
Cis-1,2,-Dichloroethene	0.00011U
Tetrachloroethene	0.054
Trichloroethene	0.00099

SB-9	1.0-1.5
1,1,1- Trichloroethane	0.1J
Cis-1,2,-Dichloroethene	0.022U
Tetrachloroethene	*11
Trichloroethene	0.17

SB-12	1.0-1.5
1,1,1- Trichloroethane	0.024J
Cis-1,2,-Dichloroethene	0.00011U
Tetrachloroethene	0.35
Trichloroethene	0.063J

SB-11	1.0-1.5
1,1,1- Trichloroethane	0.019J
Cis-1,2,-Dichloroethene	0.02U
Tetrachloroethene	*11
Trichloroethene	0.073J

SB-1	1.5-2.5
1,1,1- Trichloroethane	0.16
Cis-1,2,-Dichloroethene	0.0053U
Tetrachloroethene	23
Trichloroethene	1.4

Legend

-·-·- Approximate Site Boundary

🟨 Soil Boring Location
🟩 Proposed PDI Delineation Boring

Notes:
(1) U-The analyte was analyzed for, but not detected. Value shown is the method detection limit (MDL) for the analyzed constituent.
(2) J- Estimated concentration. The result is below the quantitation limit but above the method detection limit.
(3) UJ – The analyte was not detected above the reported method detection limit. However, based on data validation, the reported method detection limit is approximate and may or may not represent the actual limit of the detection necessary to accurately and precisely measure the analyte in the sample.
(4) Results reported in milligrams per kilogram (mg/kg).
(5) Where applicable, table lists the higher concentration from original and duplicate sample.
(6) *Red concentrations are above one or more of the following New York State Subpart 375 Soil Cleanup Objectives: Protection of Public Health (Industrial Use) or Protection of Groundwater.
(7) Specific constituents shown based on indoor air and soil vapor results and exceedences of applicable standards.

Author: PThorn Path: P:\GIS\GE\Bayshore\PDI_Workplan\Soil_VOCs.mxd

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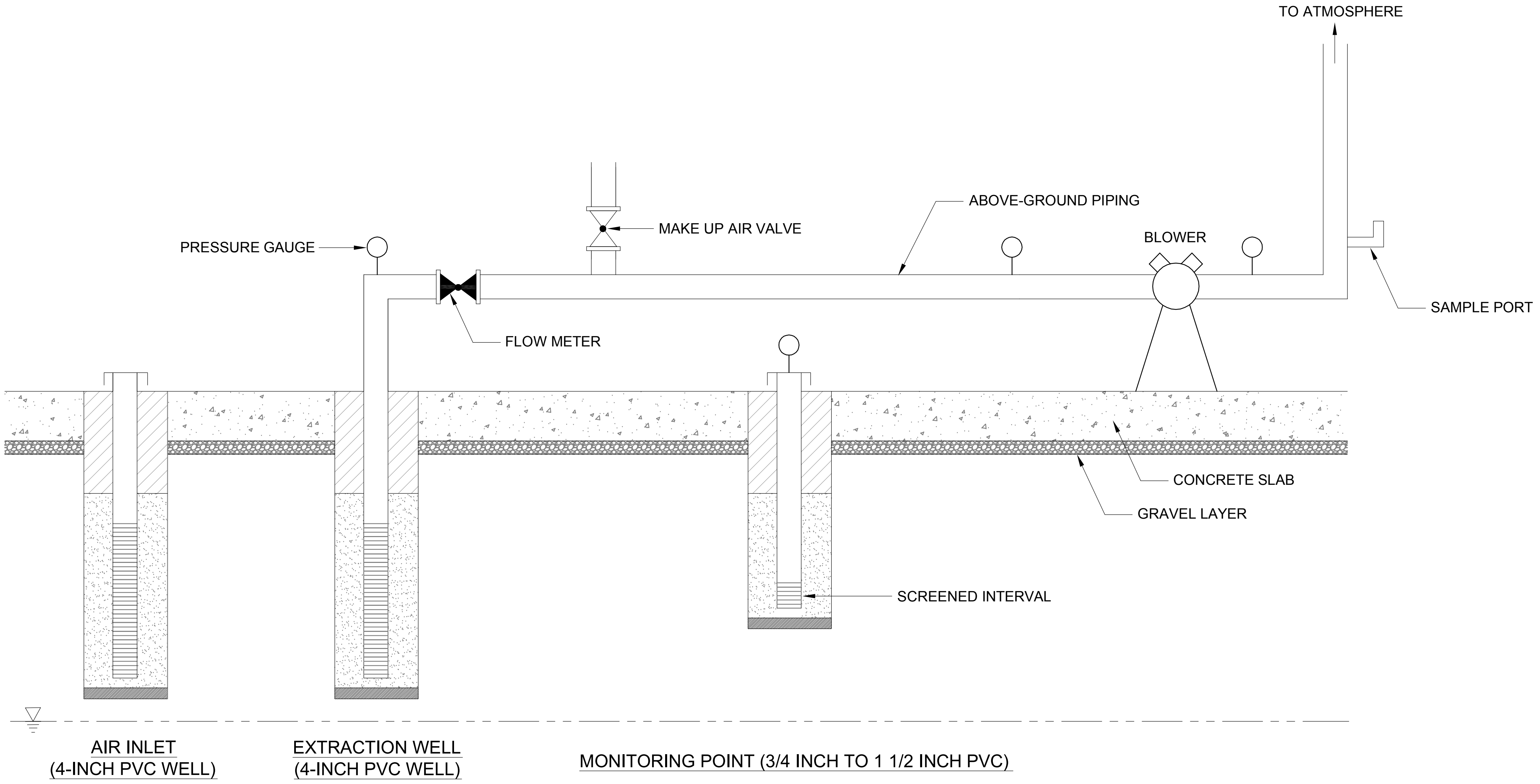
FIGURE 2-3
VOLATILE ORGANIC COMPOUNDS IN SOIL
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

FIGURE 3-1
PROPOSED INVESTIGATION LOCATIONS
FORMER BARON BLAKESLEE SITE
BAY SHORE, NEW YORK

Brown AND Caldwell

Path: P:\General_Electric\Former_Baron_Blakeslee_Site\145539_GE_Bayshore_SVE_Deliverables\PDIWorkPlan\Figures\not-used File Name: FIG-3-2 Plot Date: January 30, 2014 8:53 AM Cadd User:



Brown AND Caldwell

N.T.S.

DATE: January 30, 2014

FORMER BARON BLAKESLEE SITE
86 CLEVELAND AVENUE
BAY SHORE, NEW YORK

PRE-DESIGN INVESTIGATION
SVE TEST SCHEMATIC

FIGURE
3-2

Appendix A: Health and Safety Plan (HASP)

Health and Safety Plan for Pre-Design Investigation

Former Baron Blakeslee Potential Site
86 Cleveland Avenue
Bay Shore, NY 11706

Revision 02
January 2014

BC Project Number: 145539

Prepared by:

Brown AND Caldwell
2 Park Way, Suite 2A
Upper Saddle River, New Jersey 07458

Prepared for:

General Electric Company
319 Great Oaks Blvd.
Albany, New York 12203

Approval Page
For
Health and Safety Plan for Pre-Design Investigation
Former Baron Blakeslee Potential Site
Revision 02
January 2014

This Health and Safety Plan (HASP) has been prepared and reviewed by the following Brown and Caldwell (BC) personnel for use at: Former Baron Blakeslee Potential Site (BC Project Number: 145539).

	Name	Signature	Title	Date
Prepared By:	Catherine E. Trent		Sr. Engineer/ HS Specialist	
Reviewed By:	TO BE DETERMINED		Site Safety Officer	
Reviewed By:	Frank Williams		Project Manager	
Reviewed By:	Lydia Crabtree, CSP		Regional Safety Unit Manager	
Effective Dates:	January 2014	through	December 2014	

The effective dates of this plan are not intended to cover a period greater than 12 months.

Table of Contents

CRITICAL PROJECT INFORMATION

Primary Known Compound(s) of Concern:

- 1,1,1-Trichloroethane (1,1,1-TCA)
- Benzene
- Tetrachloroethylene (PCE)
- Toluene
- Trichloroethylene (TCE)
- Cis-1,2- Dichloroethylene (cis-1,2-DCE)

Minimum Level of Personal Protective Equipment: ☒ Level D ☐ Level C

Personal Protective Equipment:
Standard PPE for Level D consists of:

- Work shirt and long pants;
- ANSI- or ASTM-approved steel-toed boots or safety shoes;
- ANSI-approved safety glasses;
- ANSI-approved hard hat (where required on-site or when overhead hazards are present);
- Outer nitrile gloves (11 mil or thicker) and inner nitrile surgical gloves when direct contact with chemically affected soils or groundwater is anticipated (nitrile surgical gloves may be used for collecting or classifying samples as long as they are removed and disposed of immediately after each sampling event);
- Sturdy work gloves.
- High-visibility traffic safety vest.
- Full-face or half mask respirator with organic vapor cartridges (in case needed for upgrade)

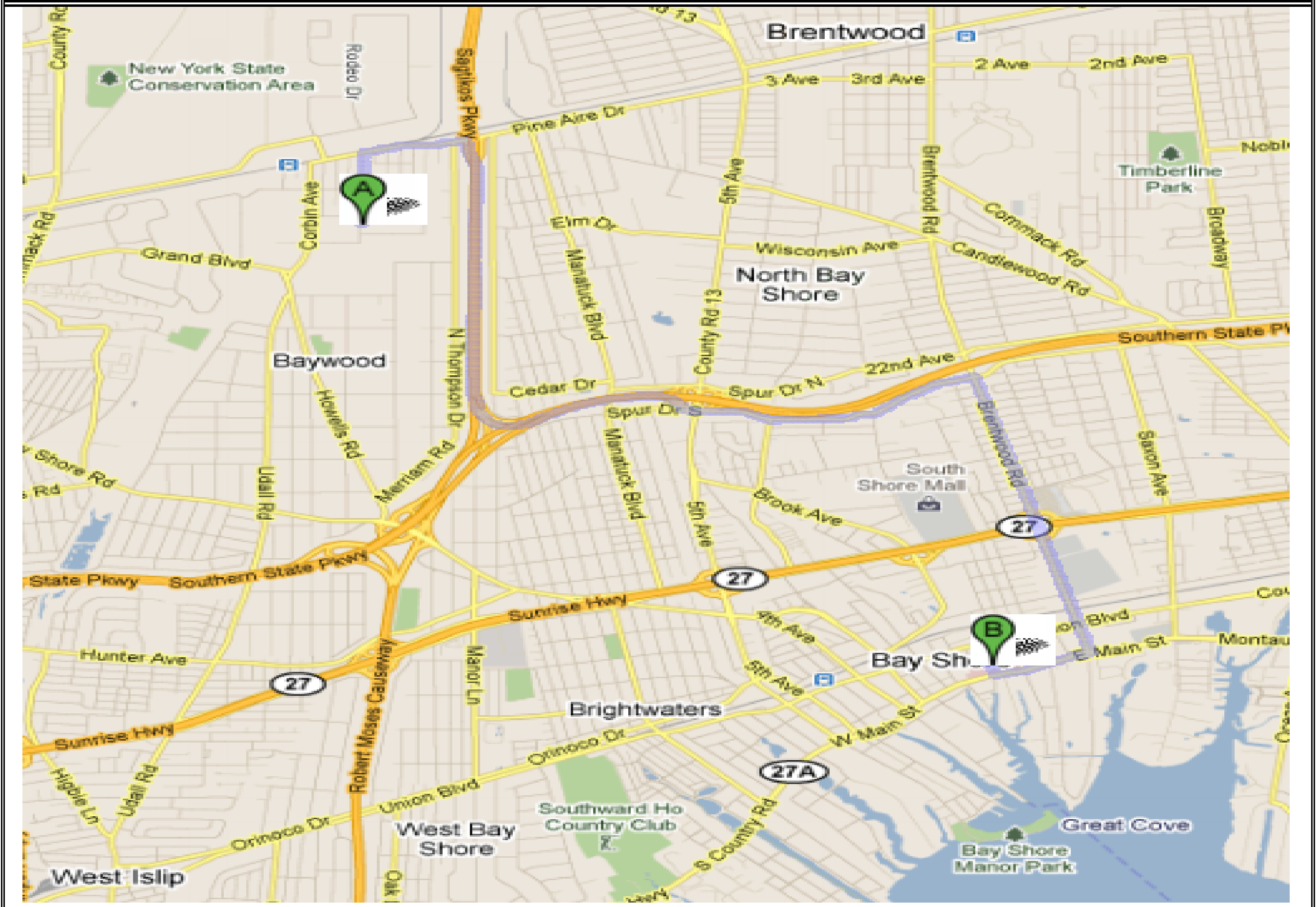
SEE SECTION 10 FOR SITE EMERGENCY CONTINGENCY PROCEDURES
Do not endanger your own life. Survey the situation before taking any action.

BC Local Office	**122 South Swan Street** **Albany, NY 12210** **Phone: 518-560-5912**
BC Regional Office	**2 Park Way, Suite 2A** **Upper Saddle River, NJ 07458** **Phone: 201-574-4700**
Site Location Address	**86 Cleveland Avenue** **Bay Shore, NY 11706**

EMERGENCY PHONE NUMBERS: In the event of emergency, contact the Project Manager and/or Regional Safety Unit Manager.

Emergency Services (Ambulance, Fire, Police)	911
Poison Control	(800) 876-4766 or (800) 222-1222
Hospital Name	Southside Hospital 301 East Main Street Bay Shore, NY 11706-8458
Hospital Phone Number	Phone: (631) 968-3000
BC Project Manager (PM): Frank Williams	Phone: 518-472-1988 Mobile: 518-339-7454
BC Site Safety Officer (SSO): To Be Determined	Phone: Cell:
BC Regional Safety Unit Manager (RSUM): Lydia Crabtree, CSP	Office: 615-250-1236 Cell: 615-202-1311
Corporate Risk Management	Property Loss Blythe Buetzow: (925) 210-2470 Injury Angela Hale: (925) 210-2218
Client Contact: General Electric John M. Uruskyj	Office: 518 862 2717 Cell: 518-527-2943
Subcontractor	
To Be Determined	Office: ***-***-**** Cell: ***-***-****
SUB CONTACTOR NAME	Office: ***-***-**** Cell: ***-***-****

HOSPITAL LOCATION MAP



HOSPITAL DIRECTIONS:

1. Head **north** on **Cleveland Ave** toward **S 3rd St** About 1 min	go 0.4 mi total 0.4 mi
2. Turn right onto **Pine Aire Dr** About 1 min	go 0.4 mi total 0.8 mi
3. Take the ramp onto **Sagtikos Pkwy** About 2 mins	go 1.6 mi total 2.4 mi
4. Take exit **S4** on the left to merge onto **Southern State Pkwy E** toward **E Islip** About 1 min	go 0.9 mi total 3.3 mi
5. Take exit **42S** toward **Bay Shore/County Road 13 S/Fifth Avenue**	go 0.1 mi total 3.4 mi
6. Slight left onto **Spur Dr S** About 3 mins	go 1.2 mi total 4.6 mi
7. Turn right onto **Brentwood Rd** About 4 mins	go 1.7 mi total 6.3 mi
8. Turn right onto **E Main St** About 1 min	go 0.4 mi total 6.7 mi
9. Turn right Destination will be on the right	go 351 ft total 6.8 mi

Southside Hospital
301 East Main Street, Bay Shore, NY 11706-8458 - (631) 968-3000

HOSPITAL INFORMATION:

Southside Hospital
301 East Main Street
Bay Shore, NY 11706-8458

Phone: (631) 968-3000

EMERGENCY FIRST AID PROCEDURES

THE RESPONDER SHOULD HAVE APPROPRIATE TRAINING TO ADMINISTER FIRST AID OR CPR

1. Survey the situation. Do not endanger your own life. DO NOT ENTER A CONFINED SPACE TO RESCUE SOMEONE WHO HAS BEEN OVERCOME. FOLLOW PROTOCOLS INCLUDING THAT A STANDBY PERSON IS PRESENT. IF APPLICABLE, REVIEW MSDSs TO EVALUATE RESPONSE ACTIONS FOR CHEMICAL EXPOSURES.
2. Call 911 (if available) or the fire department **IMMEDIATELY**. Explain the physical injury, chemical exposure, fire, or release.
3. Decontaminate the victim if it can be done without delaying life-saving procedures or causing further injury to the victim.
4. If the victim's condition appears to be non-critical, but seems to be more severe than minor cuts, he/she should be transported to the nearest hospital by the SSO or designated personnel: let the doctor assume the responsibility for determining the severity and extent of the injury. If the condition is obviously serious, contact emergency medical services (EMS) for transport or appropriate actions.

Notify the PM and Regional Safety Unit Manager immediately and complete the appropriate incident investigation reports as soon as possible.

STOP BLEEDING AND CPR GUIDELINES	
To Stop Bleeding	**CPR**
1. Give medical statement by indicating you are trained in First Aid. 2. Assure: airway, breathing and circulation. 3. Use **DIRECT PRESSURE** over the wound with clean dressing or your hand (use non-permeable gloves). Direct pressure will control most bleeding. 4. Bleeding from an artery or several injury sites may require **DIRECT PRESSURE** on a **PRESSURE POINT**. Use pressure points for 30 -60 seconds to help control severe bleeding. 5. Continue primary care and seek medical aid as needed.	1. Give medical statement by indicating you are trained in CPR. 2. Arousal: Check for consciousness. 3. Call out for help, either call 911 yourself or instruct someone else to do so. It is very important to call for emergency assistance prior to initiating CPR. 4. Open airway with chin-lift. 5. Look, listen and feel for breathing. 6. If breathing is absent, give 2 slow, full rescue breaths, 1 second per breath. 7. If breathing remains absent, initiate CPR; 30 compressions for each two breaths. Repeat for 5 cycles before re-analyzing patient or until help arrives. 8. If an automated external defibrillator (AED) is available, use it in accordance with the AED instructions.

REVISION HISTORY

Revision No.	Revision Date	Reason	Editor
0	July 2011	New Project	C.Trent/ L.Crabtree
1	October 2012	Supplemental Site Characterization	C.Spinapolice/ L.Crabtree
2	January 2014	Pre-Design Investigation	C.Trent/ L.Crabtree
3			
4			
5			

Section 1

Introduction

Brown and Caldwell (BC) has prepared this Health and Safety Plan (HASP) for use during the Pre-Design Investigational (PDI) activities to be conducted at Former Baron Blakeslee Potential Site located at 86 Cleveland Avenue, Bay Shore, NY (“the Site”). Activities conducted under BC’s direction at the Site will be in compliance with applicable Occupational Safety and Health Administration (OSHA) regulations, particularly those in Title 29 of the Code of Federal Regulations, Part 1910.120 (29 CFR 1910.120), and other applicable federal, state, and local laws, regulations, and statutes. A copy of this HASP will be kept on site during scheduled field activities.

This HASP addresses the identified hazards associated with planned field activities at the Site. It presents the minimum health and safety requirements for establishing and maintaining a safe working environment during the course of work. In the event of conflicting requirements, the procedures or practices that provide the highest degree of personnel protection will be implemented. If scheduled activities change or if site conditions encountered during the course of the work are found to differ substantially from those anticipated, the Regional Safety Unit Manager and Project Manager will be informed immediately upon discovery, and appropriate changes will be made to this HASP.

BC’s health and safety programs and procedures, including medical monitoring, respiratory protection, injury and illness prevention, hazard communication, and personal protective equipment (PPE), are documented in the BC Health & Safety Manual. The Health & Safety Manual is readily accessible to BC employees via the BC Pipeline. These health and safety procedures are incorporated herein by reference, and BC employees will adhere to the procedures specified in the manual.

BC's HASP has been prepared specifically for this project and is intended to address health and safety issues solely with respect to the activities of BC’s own employees at the site. A copy of BC's HASP may be provided to subcontractors in an effort to help them identify expected conditions at the site and general site hazards. The subcontractor shall remain responsible for identifying and evaluating hazards at the site as they pertain to their activities and for taking appropriate precautions. For example, BC's HASP does not address specific hazards associated with tasks and equipment that are particular to the subcontractor's scope of work and site activities (e.g., operation of a drill rig, excavator, crane or other equipment). Subcontractors are not to rely on BC's HASP to identify all hazards that may be present at the Site.

Subcontractors are responsible for developing, maintaining, and implementing their own health and safety programs, policies, procedures and equipment as necessary to protect their workers, and others, from their activities. Subcontractors shall operate equipment in accordance with their standard operating procedures as well as manufacturer’s specifications. Any project monitoring activities conducted by BC at the Site shall not in any way relieve subcontractors of their critical obligation to monitor their operations and employees for the determination of exposure to hazards that may be present at the Site and to provide required guidance and protection. If requested, subcontractors will provide BC with a copy of their own HASP for this project or other health and safety program documents for review.

1.1 Site History

The facility was occupied by Baron-Blakeslee, Inc., a division of Purex Corp. in 1976. Baron-Blakeslee operated a solvent storage and distribution facility which received bulk solvents and chemicals from producer facilities in New Jersey. The solvents and chemicals were pumped from trucks to twenty-nine aboveground storage tanks located on-site. Baron Blakeslee then transferred the chemicals to drums or trucks for distribution to customers. Baron-Blakeslee also maintained a recycling program, which collected non-flammable solvents from customers. The recycled solvents were temporarily stored in 55-gallon drums at the facility prior to transport to a recycling facility in New Jersey.

1.2 Site Description

The site is approximately one acre in size and contains three interconnected buildings encompassing a total of 47,000 square feet. The construction of the buildings is primarily corrugated steel with some stone walls and a concrete slab on grade foundation.

1.3 Scope of Work

The HASP addresses PDI activities as follows:

- Structual Evaluation;
- Soil Sampling
- Soil Vapor Extraction (SVE) Test; and

Field activities may include but are not limited to:

- Soil Borings/Well installation; and
- Test pit excavation

Brown and Caldwell personnel will be observing and documenting subcontractor activities, when applicable, and collecting media samples (soil, soil vapors, etc.) on an as needed basis.

Section 2

Key BC Project Personnel and Responsibilities

Frank Williams is the Project Manager (PM). Lydia Crabtree is the Regional Safety Unit Manager (RSUM). XXXXX is has been designated as the BC Site Safety Officer (SSO) for this project. An alternate SSO may be designated from the BC employees working as field staff. The BC project field staff have completed 40 hours of comprehensive health and safety training, which meets the requirements of 29 CFR 1910.120.

The responsibilities of key BC project personnel are presented below.

2.1 BC Project Manager

The PM is responsible for evaluating hazards anticipated at the Site and working with designated field staff and the RSUM to prepare this HASP to address the identified hazards. The PM is also responsible for the following.

- Informing project participants of safety and health hazards identified at the Site.
- Providing a copy of and requiring that each BC project team member, including subcontractors, reads or is briefed on the HASP.
- Checking that the BC project team is adequately trained and perform safety briefings in accordance with this HASP.
- Providing the resources necessary for maintaining a safe and healthy work environment for BC personnel.
- Communicating project safety concerns to the RSUM for determining corrective actions.

2.2 BC Site Safety Officer

The SSO has on-Site responsibility for verifying that BC team members, including subcontractors, comply with the provisions of this HASP. The SSO has the authority to monitor and correct health and safety issues as noted on-Site. The SSO is responsible for the following.

- Reporting unforeseen or unsafe conditions or work practices at the Site to the PM or RSUM.
- Stopping operations that threaten the health and safety of BC field team or members of the surrounding community.
- Monitoring the safety performance of Site personnel to evaluate the effectiveness of health and safety procedures.
- Performing air monitoring, as necessary, as prescribed in this HASP.
- Documenting field team compliance with this HASP by completing the appropriate BC forms contained in the Appendices of this document.
- Conducting daily tailgate safety meetings and assuring that project personnel understand the requirements of this HASP (as documented by each BC field team member's signature on the Signature Page).

- Limiting access to BC work areas on the Site to BC field team members and authorized personnel.
- Enforcing the “buddy system” or minimum 2-person teams as appropriate for Site activities.
- Performing periodic inspections to evaluate safety practices at the Site.
- Identifying the location and route to nearby medical facility and emergency contact information and coordinating appropriate responses in the event of emergency.

2.3 BC Regional Unit Safety Manager

The RSUM is responsible for final review and modification of this HASP. Modifications to this HASP that result in less protective measures than those specified may not be employed by the PM or SSO without the approval of the RSUM. In addition, the RSUM has the following responsibilities.

- Developing and coordinating the overall BC health and safety program.
- Advising the PM and SSO on matters relating to health and safety on this project.
- Recommending appropriate safeguards and procedures.
- Modifying this HASP, if necessary, and approving changes in health and safety procedures at the Site.

2.4 BC Team Members

BC employees and subcontractors are responsible for familiarizing themselves with health and safety aspects of the project and for conducting their activities in a safe manner. This includes attending site briefings, communicating health and safety observations and concerns to the SSO, maintaining current medical and training status and maintaining and using proper tools, equipment and PPE. Proper work practices are part of ensuring a safe and healthful working environment. Safe work practices are essential and it is the responsibility of BC employees and team members to follow safe work practices when conducting scheduled activities. Safe work practices to be employed during the entire duration of fieldwork include, but are not limited to, the following.

- Following the provisions of this HASP, company health and safety procedures and regulatory requirements.
- Reviewing safety-related information from other parties (i.e., client or contractors) as it relates to BC’s activities.
- Inspecting personal protective equipment (PPE) before on-site use, using only intact protective clothing and related gear, and changing suits, gloves, etc. if they are damaged or beyond their useful service life.
- Set up, assemble, and check out all equipment and tools for integrity and proper function before starting work activities.
- Assisting in and evaluating the effectiveness of Site procedures (including decontamination) for personnel, protective equipment, sampling equipment and containers, and heavy equipment and vehicles.
- Practice the “buddy system” as appropriate for site activities.
- Do not use faulty or suspect equipment.
- Do not use hands to wipe sweat away from face. Use a clean towel or paper towels.
- Practice contamination avoidance whenever possible.
- Do not smoke, eat, drink, or apply cosmetics while in chemically-affected areas of the site or before proper decontamination.

- Wash hands, face and arms before taking rest and lunch breaks and before leaving the site at the end of the workday.
- Check in and out with the SSO upon arrival and departure from the site.
- Perform decontamination procedures as specified in this HASP.
- Notify the SSO immediately if there is an incident that causes an injury, illness or property loss. Incidents that could have resulted in injury, illness or property loss (close call) will also be reported to the SSO.
- Do not approach or enter an area where a hazardous environment (i.e., oxygen deficiency, toxic or explosive) may exist without employing necessary engineering controls, proper PPE and appropriate support personnel.
- Use respirators correctly and as required for the Site; check the fit of the respirator with a negative or positive pressure test; do not wear respirator with facial hair or other conditions that prevent a face-to-face piece seal.
- Confined spaces will not be entered without appropriate evaluation, equipment, training and support personnel.

2.5 BC Subcontractors

Subcontractor personnel are expected to comply fully with subcontractor's HASP and to observe the minimum safety guidelines applicable to their activities which may be identified in the BC HASP. Failure to do so may result in the removal of the subcontractor or any of the subcontractor’s workers from the job site.

Section 3

Hazard Analysis

Hazards at the Site may include physical hazards, chemical hazards or biological hazards. Each type of identified hazard is addressed in the following sections. Hazards that are the specialty of a subcontractor (i.e., operation of a drill rig or excavator) are not addressed in this HASP. Subcontractors are responsible for identifying potential hazards associated with their activities and implementing proper controls.

3.1 Chemical Hazards

Exposure pathways of concern for chemical compounds that may be present at the Site are inhalation of airborne contaminants, direct skin contact with contaminated materials, and incidental ingestion of affected media. Wearing protective equipment and following decontamination procedures listed in Section 7 can minimize dermal contact and incidental ingestion. To minimize inhalation hazards, dust or vapor control measures will be implemented, where necessary, and action levels will be observed during scheduled activities. Site-specific action levels and air monitoring requirements are presented in Section 5.

Site Specific Chemical Concerns

Known or Suspected Compounds	Source	Known Concentration Range*	
		Lowest	Highest
1,1,1-Trichloroethane (1,1,1-TCA)	Groundwater	ND	2.6 ug/L
	Soil Vapor	1.9	120,000 ug/m^3
	Soil	ND	2.4 mg/kg
Benzene	Groundwater	ND	1.6 ug/L
	Soil Vapor	1.6	7.3 ug/m^3
Tetrachloroethylene (PCE)	Groundwater	ND	12 ug/L
	Soil Vapor	45	240,000 ug/m^3
	Soil	0.015	11 mg/kg
Toluene	Groundwater	ND	6.7 ug/L
	Soil Vapor	8.2	26 ug/m^3
Trichloroethylene (TCE)	Groundwater	ND	3.3 ug/L
	Soil Vapor	1.4	120,000 ug/m^3
	Soil	ND	0.22 mg/kg
Cis-1,2- Dichloroethylene (cis-1,2-DCE)	Soil	ND	2.3 mg/kg

* Known Concentration Range for Soil Vapor and Soil updated per Site Characterization Report Addendum, Former Baron Blakeslee Site, Bay Shore, New York, prepared by Brown and Caldwell Associates, dated April 2013.

Chemical descriptions of select chemicals of concern, including health effects and exposure limits, are presented in the following paragraphs. Each chemical description includes physical and odor recognition characteristics, the health effects associated with exposure, and exposure limits expressed as an 8-hour time-weighted average (TWA). Provided are federal OSHA (OSHA) permissible exposure limits (PELs; located in 29 CFR 1910.1000) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs).

3.1.1 1,1,1-Trichloroethane (1,1,1-TCA)

1,1,1-TCA (also known as methyl chloroform) is a colorless liquid with a mild odor, like chloroform. It is moderately toxic by inhalation and skin contact. It is a skin irritant and can cause central nervous system effects such as hallucinations or distorted perceptions, motor activity changes, irritability, and aggression. Gastrointestinal changes such as diarrhea, nausea, or vomiting have also been reported from 1,1,1-TCA exposure at high concentrations. Short-term exposure to 1,1,1-TCA vapor may cause headaches, dizziness, drowsiness, unconsciousness, irregular heart beat, and death. 1,1,1-TCA liquid splashed in the eye causes irritation.

Prolonged inhalation at high concentrations may affect the central nervous system and, if massively inhaled, may cause cardiac arrest. Exposure to vapors may cause mild eye irritation, and prolonged skin contact may produce irritation and dermatitis. Brief exposure to high concentrations of vapor may cause a slight loss of coordination because of its anesthetic properties.

- The OSHA PEL is listed as 350 ppm.
- The TLV is listed as 350 ppm.

3.1.2 Benzene

Benzene is a clear, volatile liquid. It is colorless, highly flammable, and toxic, with a characteristic odor. It is a severe eye and moderate skin irritant. Human effects by inhalation and ingestion include euphoria, changes in sleep and motor activity, nausea and vomiting, other blood effects, dermatitis, and fever. In industry, inhalation is the primary route of chronic benzene poisoning. If the liquid is aspirated into the lung it may cause pulmonary edema. Poisoning by skin contact has also been reported. Exposure to high concentrations (3,000 ppm) may result in acute poisoning, which is characterized by the narcotic action of benzene on the central nervous system. Chronic poisoning occurs most commonly through inhalation and dermal absorption. Benzene is a known human carcinogen that can cause leukemia.

- The OSHA PEL is listed as 1 ppm.
- The TLV is listed as 0.5 ppm.

Note: Published exposure limits designate a skin notation indicating that dermal contact can contribute to the overall exposure.

3.1.3 Tetrachloroethylene (PCE)

PCE (also known as perchloroethylene) is a colorless liquid with an ether-like odor. Short-term exposure to PCE may cause headaches, nausea, drowsiness, dizziness, incoordination, unconsciousness, irritation of the eyes, nose, and throat, and flushing of the face and neck. In addition, it may cause liver damage with such findings as yellow jaundice and dark urine. Liver damage may become evident several weeks after exposure. Skin contact may create a dry, scaly, itchy dermatitis. PCE is classified by the U.S. Environmental Protection Agency as a Group B2 probable human carcinogen.

- The OSHA PEL is listed as 100 ppm.
- The TLV is listed as 25 ppm.

3.1.4 Toluene

Toluene is a colorless liquid with a benzol-like odor. Human systemic effects of exposure to toluene include central nervous system changes, hallucinations or distorted perceptions, motor activity changes, psychophysiological changes, and bone marrow changes. It is a severe eye irritant and an experimental teratogen. Inhalation of high vapor concentrations may cause impairment of coordination and reaction time, headaches, nausea, eye irritation, loss of appetite, a bad taste in the mouth, and lassitude.

- The OSHA PEL is listed as 200 ppm.
- The TLV is listed as 20 ppm.

Note: Published exposure limits designate a skin notation indicating that dermal contact can contribute to the overall exposure.

3.1.5 Trichloroethylene (TCE)

TCE is a clear, colorless liquid with a characteristic chloroform odor. It is a mildly toxic VOC that is also an experimental carcinogen, tumorigen, and teratogen. It can cause eye effects, hallucinations and distorted perceptions when inhaled. TCE is an eye and severe skin irritant. Exposure to vapors may cause eye, nose and throat irritation. Prolonged inhalation of moderate concentrations of vapor may cause headaches and drowsiness. Inhalation of high concentrations may cause narcosis and anesthesia. Severe, acute exposure can result in cardiac failure. Significant chronic exposure may damage the liver and other organs. Prolonged repeated skin contact with the liquid may cause irritation and dermatitis.

- The OSHA PEL is listed as 100 ppm.
- The TLV is listed as 10 ppm.

3.1.6 1,2-Dichloroethene (1,2-DCE)

1,2-Dichloroethylene (1,2-DCE), a mixture of the cis and trans isomers, is a liquid with a slightly acrid odor. Available data conflict on whether there is significant difference in the toxicity from short-term exposure to trans-1,2-DCE versus cis-1,2-DCE. Narcosis has been identified as the important effect of inhalation.

- The OSHA PEL is listed as 200 ppm.
- The TLV is listed as 200 ppm.

3.2 Hazard Communication

In accordance with the Hazard Communication standard, material safety data sheets (MSDSs) will be maintained on site for chemical products used by BC personnel at the Site (i.e., spray paint, PVC cement, etc.). Subcontractors will be responsible for maintaining MSDSs for chemical products they bring on Site. In addition, containers will be clearly labeled in English to indicate their contents and appropriate hazard warnings. Please note that labeling containers includes, but is not limited to, any waste, used PPE, and/or decontamination materials collected.

3.3 Opening Wells and Well Vaults

Direct-reading instrumentation specified in Section 5 will be used to monitor any work in a well vault at the site where VOCs are a concern. The well vault will be opened carefully with the BC employee staying upwind as much as possible and then left open for a minimum of three minutes to allow the vault to vent. If the well cap is then removed, allow another three minutes for the well head to vent before proceeding. Please note that if there are other established protocols that differ from 3 minutes; the more protective time increment will be followed. Personnel should stay upwind as much as possible while working in and around the vault.

When removing a well cap, personnel will remain upwind as much as possible and will carefully remove the cap by opening it away from them in order to minimize the likelihood of exposure to vapors. Personnel will wait a minimum of three minutes to allow the well to vent before proceeding.

3.4 Physical Hazards

The following physical hazards, as marked below, have been identified and may be encountered during scheduled field activities.

☒ Slips, Trips and Falls
☒ Heavy Equipment
☒ Excavations
☒ Noise
☒ Overhead Utilities
☒ Electrical Hazards
☐ Confined Spaces
☒ Sharp Objects/Cutting Utensils
☐ Elevated Platforms/Working Surfaces
☒ Traffic
☐ Arc Flash Protection
☐ Water Hazards (non-boating)
☐ Removing Manhole Covers
☒ Housekeeping
☒ Materials and Equipment Handling - Lifting
☒ Drilling
☒ Underground Utilities
☐ Equipment Refueling
☐ Lockout/Tagout
☐ Fire/Explosion
☒ Cutting Acetate Sleeves
☒ Ladder Use
☒ Driving
☐ Boating Safety
☐ Building Collapse
☐ Personal Safety – Urban Setting

Actions to be taken to protect against the hazards identified are provided in the sections below.

3.4.1 Slip, Trips and Falls

Slipping hazards may exist due to uneven terrain, wet or slick surfaces, leaks or spills. Tripping hazards may be present from elevation changes, debris, poor housekeeping or tools and equipment. Some specific hazards may include: climbing/descending ladders, scaffolding, berms or curbing. Collectively, these types of injuries account for nearly 50 percent of all occupational injuries and accepted disabling claims. Prevention requires attention and alertness on the part of each worker, following and enforcing proper procedures, including good housekeeping practices, and wearing appropriate protective equipment.

3.4.2 Housekeeping

Personnel shall maintain a clean and orderly work environment. Make sure that all materials stored in tiers are stacked, racked, blocked, interlocked, or secured to prevent sliding, falling, collapse, or overturning. Keep aisles and passageways clear and in good repair to provide for free and safe movement of employees and material-handling equipment. Do not allow materials to accumulate to a degree that it creates a safety or fire hazard.

During construction activities, scrap and form lumber with protruding nails and other items shall be kept clear from work areas, passageways, and stairs. Combustible scrap and debris shall be removed at regular intervals. Safe means must be provided to facilitate removal of debris.

Containers must be provided for collecting and separating waste, used rags and other debris. Containers used for garbage and other oily flammable or hazardous waste such as caustics, acids, harmless dusts, etc., must be separated and equipped with covers. Garbage and other waste shall be disposed of at frequent and regular intervals.

3.4.3 Heavy Equipment

Equipment, including earth-moving equipment, drill rigs, or other heavy machinery, will be operated in compliance with the manufacturer's instructions, specifications, and limitations, as well as any applicable regulations. The operator is responsible for inspecting the equipment prior to use each work shift to verify that it is functioning properly and safely.

The following precautions should be observed whenever heavy equipment is in use:

- PPE, including steel-toed boots, safety glasses, high visibility vests, and hard hats must be worn.
- Personnel must be aware of the location and operation of heavy equipment and take precautions to avoid getting in the way of its operation. Workers must never assume that the equipment operator sees them; eye contact and hand signals should be used to inform the operator of the worker's intent.
- Personnel should not walk directly in back of, or to the side of, heavy equipment without the operator's knowledge. Workers should avoid entering the swing radius of equipment and be aware of potential pinch points.
- Nonessential personnel will be kept out of the work area.

3.4.4 Materials and Equipment Handling - Lifting

The movement and handling of equipment and materials on the Site pose a risk to workers in the form of muscle strains and minor injuries. These injuries can be avoided by using safe handling practices, proper lifting techniques, and proper personal safety equipment such as steel-toed boots and sturdy work gloves. Where practical, mechanical devices will be utilized to assist in the movement of equipment and materials. Workers will not attempt to move heavy objects by themselves without using appropriate mechanical aids such as drum dollies or hydraulic lift gates.

Proper lifting techniques include the following:

- Lift with the strength of your knees, not your back.
- Firmly plant your feet approximately shoulder-width apart.
- Turn your whole body, don't bend or twist at the waist.
- Be sure that the path is clear of obstructions or tripping hazards; avoid carrying objects that will obstruct your vision.
- Use caution when holding an object from the bottom to prevent crushing of the hands or fingers when lowering.

3.4.5 Excavations

A competent person who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them, will be present during excavation activities.

The atmosphere will be tested in excavations, before employees are permitted to enter and begin work, greater than 4 feet in depth or where oxygen deficiency or toxic or flammable gases are likely to be present. The atmosphere shall be ventilated and re-tested until flammable gas concentrations less than 5 percent of the lower explosive limit (LEL) and site-specific action levels are obtained. Worker entry will not be allowed if the oxygen concentration is less than 20 percent. In addition, a safe means of access and egress (i.e., a ladder, stairs or ramp) must be provided so that no more than 25 feet of lateral travel is required by employees.

Workers will not enter unstable excavations or excavations greater than 5 feet in depth without appropriate protective systems such as benching, sloping, or shoring. If shoring or shielding systems are not used, side slopes will not be steeper than 1½:1 without written confirmation from the competent person that the slope is safe for the soil conditions. Excavations will be constructed in accordance with the OSHA Excavation Safety Standard (29CFR1926 Subpart P).

The competent person will inspect excavations daily. If there is evidence that a cave-in or slide is possible, work will cease until the necessary safeguards have been taken. Excavated material will be placed far enough from the edge of the excavation (a minimum of 2 feet) so that it does not fall back into the opening or affect the integrity of the sidewall. At the end of each day's activities, open excavations will be clearly marked and secured to prevent nearby workers or unauthorized personnel from entering them. Remote sampling techniques will be the preferred method of sample collection in excavations.

3.4.6 Drilling

During all drilling activities, the operator must verify that the appropriate level of protection and appropriate safety procedures are utilized. The operator will verify that equipment "kill switches" are functioning properly at the start of each day's use. Hard hats, steel-toed boots, and ear and eye protection will be required at all times when working around drill rigs. The proximity of underground and overhead utilities must be identified before any drilling is attempted. The rig may not be moved with the mast in the upright position.

Workers can effectively manage hazards associated with working around heavy equipment if a constant awareness of these hazards is maintained. These hazards include the risk of becoming physically entangled in rotating machinery, slipping and falling, impact injury to eyes, head and body, and injury from machinery operations. Never work or walk on piles of well casings. Make sure all high-pressure lines and hoses have whip checks attached. Constant visual or verbal contact with the equipment operator will facilitate such awareness.

3.4.7 Noise

Noise may result primarily from the operation of heavy equipment, process machinery or other mechanical equipment. Hearing protection with the appropriate noise reduction rating (NRR) shall be worn in areas with high noise levels. A good rule of thumb to determine if hearing protection is needed is the inability to have a conversation at arms length without raising voice levels. If loud noise is present or normal conversation becomes difficult, hearing protection in the form of ear plugs, or equivalent, will be required.

3.4.8 Underground Utilities

Reasonable efforts will be made to identify the location(s) of underground utilities (e.g., pipes, electrical conductors, fuel lines, and water and sewer lines) before intrusive soil work is performed. The state underground utility notification authority (e.g., USA, Dig Alert, Blue Stake, etc.) will be contacted prior to the start of intrusive field activities in accordance with local notification requirements. In areas not evaluated or serviced by the underground utility notification authority, and a reasonable potential for underground utilities exists, one or more of the following techniques will be employed to determine the location of subsurface structures.

- Contracting the services of a qualified private utility locator.
- Having a survey of the subject area conducted by staff trained in the use of subsurface utility locating equipment.

- Subsurface testing (i.e., hand digging or potholing) to the expected depth of probable utilities (not less than 5 feet).

If utilities cannot be located or if unlocated utilities are suspected to be present, subsurface activities (i.e., borings, excavation) should not be conducted before the location(s) or absence of underground utilities is confirmed.

Typical subsurface location marks are as follows:

- Red – electrical,
- Yellow – gas/oil/steam,
- Blue – water,
- Green – sanitary/storm drains/culverts,
- Orange – communications, and
- White – proposed excavation or boring.

Intrusive work should be limited to the area 3.3 feet (1 meter) on either side of the location marks. In some special cases such as fiber optics and high-pressure pipelines this area should be expanded to 16.5 feet (5 meters) on either side of the utility.

3.4.9 Overhead Utilities

If work is to be conducted in the vicinity of overhead electrical utilities, the owner of the overhead line will be contacted to determine the maximum voltage. Any overhead utility will be considered to be energized unless and until the person owning or operating such line verifies that the line is not energized, and the line is visibly grounded at the work site.

Workers will not perform work in proximity to energized high-voltage lines (including scaffolding, well drilling, pile driving, or hoisting equipment) until danger from accidental contact with high-voltage lines has been effectively guarded against.

Equipment with articulated upright booms or masts are not permitted to operate within 15 feet of an overhead utility line (less than 50kV) while the boom is in the upright position. For transmission lines in excess of 50kV, an additional distance of 4 inches for each 10 kV over 50kV will be used.

3.4.10 Equipment Refueling

Care shall be exercised while refueling generators, pumps, vehicles, and other equipment to prevent fire and spills. Personnel shall eliminate static electricity by grounding themselves (touching metal) prior to using refueling hoses and or containers of petroleum liquids. Items being refueled shall be grounded or be located on the ground and not on a trailer, work bench or inside a truck bed. Equipment that is hot must be allowed to cool prior to refueling. Spill response materials shall be available when conducting refueling operations.

3.4.11 Electrical Hazards

Electrical equipment to be used during field activities will be suitably grounded and ed. Ground-fault circuit interrupters (GFCI), or equivalent, will be used with electrical equipment to reduce the potential for serious electrical shock. Electrical equipment including batteries, generators, panels and extension cords shall be kept dry during use. Extension cords may not be used as a permanent means of providing power and will be removed from service if they are worn, frayed, or if the grounding prong is missing.

Extension cord precautions include the following:

- Be aware of exposed or bare wires, especially on metal grating. Warning: Electrical contact with metal can cause fatal electrocution.
- Prior to use, inspect cords for exposed or bare wires, worn or frayed cords, and incorrect splices. Splices are permitted, but there must be insulation equal to the cable, including flexibility.
- Cables and extension cords in passageways, steps or any area where there may be foot traffic should be secured so as to not create a tripping hazard. Overhead cables and extension cords shall be rigged to a height greater than 6 feet.
- Shield extension cords that must run across driveways or areas where vehicle traffic is present.
- Do not run cords across doorways or windows where they can be frayed or cut by a closed door or window.
- Do not run wires through wet or puddled areas.
- Flexible cord sets that are used on construction sites or in damp locations shall be of hard usage or extra hard usage type.

Observation of energized machinery will take place from a safe distance. Only qualified personnel will remove guards, hatch covers, or other security devices if necessary. Equipment lockout procedures and the appropriate facility work permit requirements will be followed. Lockout/tagout procedures will be conducted before activities begin on or near energized or mechanical equipment that may pose a hazard to site personnel. Workers conducting the operation will positively isolate the piece of equipment, lock/tag the energy source, and verify effectiveness of the isolation. Only employees who perform the lockout/tagout procedure may remove their own tags/locks. Employees shall complete lockout/tagout training before initiating this procedure.

Only qualified personnel will remove covers of electrical equipment to expose energized electrical parts. Entering electrical rooms/vaults or areas with live exposed electrical part by BC employees shall be permitted only when accompanied by a qualified personnel after notification and approval of the appropriate facility personnel.

3.4.12 Lockout/Tagout

Lockout/tagout (LO/TO) procedures in accordance with 29 CFR 1910.147 will be performed before activities begin on or near energized or mechanical equipment that may pose a hazard to site personnel. The purpose of the lockout/tagout (LO/TO) system is to safeguard exposure from machinery, energized electrical circuits, piping under pressure, or any type of energy source from unexpected energization or start up that could cause harm to an individual. Workers conducting the operation will positively isolate the piece of equipment, lock/tag the energy source, and verify effectiveness of the isolation. Only employees who perform the lockout/tagout procedure may remove their own tags/locks. Employees must be thoroughly trained before initiating this procedure.

Whenever multiple personnel (or multiple employers are working on the same worksite) are to be engaged in activities requiring LO/TO, employees/employers shall inform each other of their activities and coordinate their respective LO/TO procedures. When applicable, BC shall request an owner’s representative to initiate the LO/TO procedure and apply the first lock. When initiated by others, BC will remove their locks prior to leaving a facility. Whenever a group lockout/tagout procedure must be performed, they shall utilize a procedure that affords the same level of protection as that provided by the implementation of a personal lockout or tagout device. Group LO/TO devices shall meet the requirements of 29 CFR 1910.145(f)(3).

Basic Lockout/Tagout Procedures

1. Each person will maintain their own lock, key, and lockout device so that no one else can remove the lock.

2. Always notify the operator when work is to be done.
3. Use your own lock to lock out electrical power. Attach a tag or sign to the power disconnect to indicate that maintenance work is in progress. Use the wording “Do Not Operate.”
4. Bleed all pressure from pneumatic, hydraulic, or other fluid lines, or safely isolate them from the area where work is being done.
5. Drain contents of lines or tanks as needed. Lock valves open or closed to prevent buildup of pressure.
6. Ground electrical systems as needed.
7. Secure any device under tension or compression so as to prevent accidental movement. Move suspended parts that could drop or cycle to a safe position and block, clamp, or chain them in place.
8. Verify (test) that the mechanism has been isolated from the source of energy.
9. Ensure that all workers remove their individual locks after work is completed. The last worker should remove the locking devices.
10. Ensure that the last person double-checks that all is clear and safe before start-up.

Portable Equipment

Portable electrical equipment such as hand drills, computers, and power saws that use plug type connectors must be unplugged prior to any task that may expose the employee to energized portions of the equipment. Removal of the plug from the power source, such as the generator or wall socket, may be combined with a tagout system, particularly if the plug is at a distance from the equipment being repaired

3.4.13 Confined Spaces

Entry into confined spaces will be conducted in strict accordance with 29 CFR 1910.146. Confined spaces will be evaluated prior to entry to determine if hazards are present that could pose a risk to entrants. Before workers may enter a permit-required confined space, an entry permit must be completed by the PM or SSO, approved by the RSUM and, all requirements for entry must be met.

- Confined spaces may be described as having, but not being limited to, the following characteristics:
- is large enough to permit an employee to enter and perform work; and
- has limited or restricted means of entry and exit; and
- is not equipped, designed, or intended for continuous human occupancy.

If there is any serious health and safety hazard present in the confined space, the space is considered a permit-required confined space (permit space). A permit-space is a confined space that has one or more of the following characteristics:

- contains or has the potential to contain a hazardous atmosphere; or
- contains or has the potential to contain a material with the potential to engulf or entrap an employee; or
- is so configured that an employee may become trapped, disoriented, or asphyxiated by wall configurations or floors that taper to smaller cross sections; or
- contains any other established safety or health hazard (examples may include sources of energy, moving parts or thermal considerations).

All fluid, electrical, and steam lines and other sources of energy that could harm entrants must be completely isolated before entry. The following atmospheric conditions must be met before entry is permissible (air monitoring may be necessary to verify these conditions are met):

- flammable vapor or dust must be at a concentration less than 5 percent of the lower explosive limit (LEL); and
- oxygen must be at a concentration greater than 20 percent and less than 22 percent; and
- hydrogen sulfide concentration must be less than 5 parts per million (ppm); and
- toxic substances must be at a concentration less than half their respective permissible exposure limits or specified action limits.

In addition, the following roles must be designated before entry into permit-required confined spaces is allowed: Entry Supervisor; Attendant; and Authorized Entrant(s). Confined space entry for each project also requires training for the project team on written operating procedures, including the use of the Confined Space Entry Permit form.

BC employees are not trained in rescue services. Such services are to be arranged locally, prior to entry operations, by the PM. Rescue services can typically be provided by the local fire department or contracted service provider.

3.4.14 Fire/Explosion

Site workers should have an increased awareness concerning fire and explosion hazards whenever working with or near flammable materials, especially when performing any activity that may generate sparks, flame, or other source of ignition. Intrinsically safe equipment is required when working in or near environments with the potential for an explosive or flammable atmosphere. The SSO will verify facility requirements for a “hot work” permit before activities that may serve as a source of ignition are conducted.

Flammable materials will be kept away from sources of ignition. In the event of fire, work will cease, the area will be evacuated, and the local fire response team will be notified immediately. Only trained, experienced fire fighters should attempt to extinguish substantial fires at the Site. Site personnel should not attempt to fight fires, unless properly trained and equipped to do so. A fully charged ABC dry chemical fire extinguisher will be readily available for use during all scheduled activities at the Site.

3.4.15 Sharp Objects/Cutting Utensils

Frequently field tasks require the cutting of items such as rope, packaging or containers. Care should be exercised in using knives and/or cutting implements while performing such cutting tasks. Personnel should cut down and away from their body and other personnel. The item being cut should be braced or secured from movement while cutting. When slicing open acetate liners, such as those utilized in direct push drilling, personnel should use a hook blade cutting implement designed for this task versus a straight blade knife.

3.4.16 Cutting Acetate Sample Sleeves

The cutting of acetate sleeves presents a potential hazard to sampling personnel. By following proper procedures, the risk associated with this activity can be effectively minimized. To remove the soil sample the acetate liner must be cut with a bladed tool or knife. Knives are more frequently the source of disabling injuries than any other hand tool. The principal hazard in the use of knives is the hand slipping from the handle onto the blade or the blade strikes another part of the body. To prevent this, the following safety procedures should be followed:

- Provide a safety blade holder with a retraction spring on a track where blade mounts. Use a hook type linoleum blade which has a reduced cutting edge. When the hook of the blade is cutting the acetate liner it keeps the blade extended. If the blade breaks or the operator's hand slips the blade automatically retracts into the handle of the safety blade holder.

- Replace blades when they become dull. If material becomes hard to cut then the blade is dull.
- Wear leather cut-resistant (such as Kevlar) gloves.
- Wear safety glasses.
- The cutting stroke should be away from the body. If that is not possible, then the hands and body should be in the clear.
- Provide an angle iron device to place the liner in when cutting. This gives a holder for the liner.
- If you drop the knife, just let it fall to the ground and DO NOT try to catch it.
- If you lay the knife down, make sure the blade is retracted into the holder or the knife is placed in a protective holder.

3.4.17 Elevated Platforms / Working Surfaces

When working at heights that expose employees to falls greater than 6 feet, especially on sloping roofs and elevated platforms, the requirements of 29 CFR 1926.502 shall be observed. In such instances, a safety harness shall be worn and the lanyard secured at a level not lower than the employee's waist, limiting the free-fall distance to a maximum of 6 feet.

Elevated work platforms shall be constructed, used, and maintained in accordance with Subpart L of the OSHA Construction Safety Orders. Scaffolds and hoisting lines shall be inspected daily by a competent person to verify the integrity of the components. If a material is determined to be defective, it may not be used for any purpose and will be replaced immediately.

A standard railing shall consist of top rail, intermediate rail, toe board, and post. It shall have a vertical height of approximately 42 inches (±3 inches) from the top surface of the top rail to the floor, platform, runway, or ramp. The top rail shall have a smooth surface throughout. The intermediate rail shall be set half way between the top rail and the floor, platform, runway, or ramp.

A cover of standard strength and construction that is secured against accidental displacement shall guard floor holes, hatchways, or any other openings into which a person can walk. When the cover is not in place, the openings shall be guarded with a standard railing (equipped with a toe board) on all exposed sides. Any cover on floor openings shall be properly labeled or stenciled with letters at least one inch high or greater stating "OPENING – DO NOT REMOVE".

<u>Personal Fall Protection Equipment</u>

Full body harness is the only acceptable means of fall arrest for personnel working over surfaces greater than six feet in height. A Fall Arrest System consisting of safety harness and anchor lanyard must be worn by anyone working on elevated surfaces that lack "general" fall protection such as railings, etc.

Lanyards must be tied off at a point above the worker's head and to a firm structure or a portion thereof designed to hold a weight of 5,000 lbs. Only hooks with locking snaps that operate in "as new" condition will be used. These hooks are also referred to as "double action lanyard hooks".

When other possible means of fall protection (railings, etc.) are not available, individuals working at heights of less than 6 feet must tie-off if there is danger of impalement, especially if the impalement hazard cannot be mitigated in accordance with OSHA standards.

All workers must perform routine inspection of belts/harnesses and lanyards prior to their use. The employer shall conduct regular inspections (every three months) of all fall protection equipment. In addition, there shall be an inspection of all workers' personal tools and equipment prior to the employees using them on the job.

Lanyards are to be used for tie-off purposes only, and damaged belts, harnesses, and lanyards must be retired and discarded.

3.4.18 Ladder Use

Ladders are to be maintained in good condition at all times, with tight joints, hardware, and fittings securely attached, and moveable parts freely operating without binding or undo play. Defective ladders must be "tagged" out of service. Safety "feet" shall be kept in good condition. Ladders are to be visually inspected for possible signs of damage or defects daily, before each use.

Where possible, portable straight rung ladders shall be set up so that the horizontal distance from the top support to the foot of the ladder is ¼ of the working length of the ladder. The ladder shall be secured by tying it off to a firm point, or held in place by another worker while in use. If the ladder is used to gain access to a roof or platform, the side rails shall extend at least 3 feet beyond the point of support at the edge of the roof or platform.

Step ladders shall always be set up properly, so that they are in the "A" frame position, level and with all four feet on firm ground, and fully opened with the spreaders locked in place. Personnel are forbidden to stand on the top cap or on the last step of a step ladder, or to stand on the hinged back of a step ladder. A step ladder shall never be used at a straight ladder.

3.4.19 Traffic

Vehicular traffic presents opportunities for serious injury to persons or property. Traffic may consist of street traffic or motor vehicles operated by facility employees or visitors to the Site. Workers and other pedestrians are clearly at risk during periods of heavy traffic. Risk from motor vehicle operations may be minimized by good operating practices and alertness, and care on the part of workers and pedestrians.

Site personnel will wear high-visibility traffic safety vests whenever activities are conducted in areas of heavy traffic. Work vehicles will be arranged to be used as a barrier between site workers and nearby traffic. If required by local ordinances or site location, a traffic control plan will be developed and implemented. Consider using amber/yellow warning lights to alert traffic to the work zone. Note that amber/yellow warning lights may be required by specific clients or ordinances.

It is important to be conscious of all vehicular traffic that may be present during conduct of field operations. Use caution tape, barricades, or safety cones to denote the boundaries of the work area and to alert vehicle operators to the presence of operations which are non-routine to them. Be careful when exiting the work area and especially when walking out from between parked vehicles to avoid vehicular traffic.

Never turn your Back on Traffic. When working in or near a roadway, walk and work with your face to the oncoming traffic. If you must turn your back to traffic, have a coworker watch oncoming traffic for you.

Vehicle and Worksite Position. Whenever possible, place a vehicle between your worksite and oncoming traffic. Not only is the vehicle a large, visible warning sign, but if an oncoming car should fail to yield or deviate, the parked vehicle, rather than your body, would absorb the first impact of a crash. Turn the wheels so that if the vehicle were struck, it would swing away from the worksite. Even though the vehicle would protect you in a crash, it might be knocked several feet backward. Always leave some room between the rear of the vehicle and the work area.

Use of Signs and Cones to Direct Traffic. Traffic signs and cones are used to inform drivers and direct traffic away from and around you. Cones and signs are only effective if they give oncoming drivers enough time to react and make it clear how traffic should react.

Cone Positioning. The most common coning situation is setting a taper of cones that creates a visual barrier for oncoming motorists and gradually closes a lane.

The position of the taper depends on the road width, position and size of the work area, and also on the characteristics of the traffic.

3.4.20 Driving

A lot of driving is required to get to, from, and between project Sites. Safe vehicle maintenance and operation must be a priority. It requires knowledge of directions to (and conditions of) the Site in advance, careful exiting and merging into traffic, anticipating the unexpected, remaining alert to one's physical and mental condition, resisting distractions such as cell phone use, other car activities and contacting assistance when needed. Report all vehicle colllisions/incidents to BC's Risk Manager.

3.4.21Arc Flash Protection

An arc flash is a short circuit through the air when insulation or isolation between electrified conductors is breached or can no longer withstand the applied voltage. Statistics show that there are 5 to 10 arc flash explosions a day near electrical equipment that result in hospitalization of a burn victim. An arc flash can be caused by common occurrences such as dropping tools, accidental contact with electrical systems, and build up of dirt or corrosion.

The temperature of an arc can reach more than 35,000 F as it creates a brilliant flash of light and a loud noise. Concentrated energy explodes outward from the electrical equipment, spreading hot gases, molten metal, causing death or severe burns, and creating pressure waves that can damage hearing or brain function and a flash that can damage eyesight. The fast-moving pressure wave also can send loose material such as pieces of equipment, metal tools, and other objects flying, injuring anyone standing nearby.

Regulations require the calculation of the "flash protection boundary" inside which qualified workers must be protected when working. This boundary is an imaginary sphere surrounding the potential arc point, "within which a person could receive a second-degree burn if an electrical arc flash were to occur," according to the National Fire Protection Association (NFPA) 70E standard. Brown and Caldwell's Health and Safety Manual gives direction of when and where to establish this boundary.

BC's Electrical Safety/Arc Flash Policy provides information and instruction for BC employees who work on or near energized power circuits, electrical distribution equipment, electrical utilization equipment and those who inspect energized equipment, where a phase-to-ground or phase-to-phase short or fault occurrence may cause an Arc Flash event.

BC employees must comply with BC's Electrical Safety and Lock-Out/Tag-Out Policy in the Health and Safety Manual and treat electrical equipment and circuits as energized until:

1. Lock-Out/Tag-Out protection is in place and the equipment or circuit has been tested to verify "no voltage" present, by a trained and qualified electrical worker, or
2. The equipment or circuit has been physically isolated from every power source, tested, and clearly labeled.

For those BC employees involved with energized electrical work (i.e. design verification, equipment check-out, or start-up adjustments), the following ordered approach must be used:

1. BC employees will seek to have a trained and qualified electrical worker perform all energized electrical hands-on work (i.e. switching, metering, testing, etc.) while BC employees remain outside the flash protection boundary, with the exception of those BC employees who have completed NFPA 70 E and have appropriately planned, including appropriate PPE, for the task.
2. BC employees that closely supervise work within the flash protection boundary should document the possible electrical hazards, appropriate PPE, and mitigation techniques to be implemented during the project with a detailed project work plan attached to this plan's appendicies. The Electrical Safe-

ty Officer (ESO) or similarly qualified person must approve all project work plans with identified shock or arc flash hazards.

3. Prior to performing this work, the Project Manager (PM) will verify that the above-mentioned project work plan is prepared and approved and reviewed by the PM, the project field team, the SSO, and cognizant Health and Safety Manager.
4. Only BC employees with NFPA 70E Qualified Person training shall enter the flash protection boundary wearing the proper Personal Protective Equipment (PPE) and only for Hazard/Risk Categories 0-2 – see the 'Warning' section below.

WARNING

Qualified BC personnel are limited to work in Hazard/Risk Categories 0-2, and therefore only require PPE meeting the requirements of Hazard/Risk Categories 0-2.

Only qualified electricians may conduct work categorized as a Hazard/Risk Category of 3 or 4.

Qualified BC personnel are NOT to cross a flash protection boundary which involves a Hazard/Risk Category 3 or 4 situation.

BC employees and management shall review the Arc Flash policy in BC's Health and Safety Manual for detailed requirements.

Questions concerning this policy should be directed to the BC Electrical Safety Officer RSUM.

Definitions

Energized Electrical Work. Work performed on or near energized electrical systems or equipment with exposed components operating at 50 volts or greater. Electrical system testing, thought to be de-energized, but not yet proven to be (for example, a LO/TO effectiveness check).

Flash Protection Boundary. The distance from energized exposed electrical equipment at which an unprotected person will receive a curable burn: 2nd degree burn or blistering. Work performed inside this boundary requires that the person be a "qualified person" and the use of appropriate personal protective equipment (PPE) to protect against arc flash burns.

Newly installed/serviced electrical equipment may contain an Arc Flash Label that will identify the energy, hazard category and PPE requirements associated with the equipment. For all other unlabeled equipment, where the specific flash protection boundary (energy, hazard category, and applicable PPE) is not established or cannot be established first (prior to live electrical exposure), BC personnel must maintain a 4-foot minimum observation distance (10 feet is preferred) from the exposed (i.e. doors open, covers off) live electrical equipment rated 600V and below. In the event that the flash protection boundary must be crossed, qualified BC personnel will don PPE appropriate for Hazard/Risk Category 2. For equipment rated above 600V, BC personnel must maintain a 10-foot minimum observation distance and not enter the flash protection boundary unless qualified and approved to do so.

Qualified BC Employee. A person with the training and experience having knowledge of energized electrical equipment hazards from an operational standpoint and from the safety training standpoint.

Educational credentials alone do not make a person qualified. Determination of qualification must be established by the employee's supervisor or other designated knowledgeable management representative.

3.4.22 Boating Safety

Boating or similar activities on aerated water treatment ponds and/or tanks by BC personnel is not permitted. The aeration process affects the buoyancy of the liquid and therefore boats can not consistently stay afloat.

Performing work activities from a boat can present unique hazards to employees. The following guidelines can help mitigate the risk. The boat can become unstable if the weight in it is excessive or loaded improperly. Too much weight will reduce maneuverability and freeboard (the height of the boat sides above the water) and can increase the risk of sinking.

When boarding the boat, the operator must be sure that the boat is secure. With one hand on the boat, each employee should quickly lower themselves straight down into the center of the boat. A United States Coast Guard (USCG) certified personal floatation device will be worn by each BC employee in the boat. In addition, other USCG-required items (i.e., throwable cushion, retrieval line, etc.) will be present on the boat. To move around in a boat, one should step along the fore-and-aft centerline of the boat while the boat is held in place along the pier.

Do not board the boat while carrying equipment, rather first board the craft and then have someone hand in the equipment or place the equipment in the boat prior to launch The amount and location of weight is critical and can reduce the risk of capsizing. Weight should be kept towards the middle or centerline of the boat, both fore and aft and side to side, also the weight should be kept low to the bottom of the boat to reduce the center of gravity.

It is not anticipated that waves of substantial size will be encountered, however, if a wave approaches the boat, steer the bow towards the oncoming wave. Overloading the boat increases draw and the potential for swamping. Watercraft must be operated within the boat manufacturers weight limits.

Should the boat capsize, Brown and Caldwell personnel shall abandon the boat and return to shore as quickly as possible. It is important that the employees attempt to remove themselves from the water as soon as possible, and get inside and call for help. Hypothermia (cold stress) is a significant risk for anyone involved in a boating mishap due to the rapid conduction of body heat by cold water. Wet or dry suits are recommended for cold weather/cold water (less than 45° F) operations.

3.4.23 Water Hazards (non-boating activities)

Wading in streams poses a few natural hazards such as uneven terrain, and potentially dangerous water levels. Field work should be halted when there has been significant rainfall within the past 24 hours or during the course of a work day. The potential for rapidly rising water levels is present in many of these streams/rivers within the project area. SSO shall evaluate field conditions after a rainfall and halt field work if there is the possibility of the development of a hazardous condition.

Open Water

Streams or stormwater ditches may be located near freeways and highways. High stream flows commonly associated with storm events present a threat to workers. Slippery conditions, streamside vegetation, and unstable stream banks could cause a worker to fall into a stream. The risks of a fall include bodily injury, hypothermia and drowning. Work in and around streams will require the use of the buddy system for safety purposes. During storm events that cause streams and rivers to rise to dangerously high conditions, employees should discontinue their work until safe working conditions resume. Prior to entering water, employees must evaluate the need to wear PFDs, rubber boots, or waders and use them as is deemed necessary based on conditions present. Some factors to consider when evaluating the need to wear a PFD are stream current speed, stream bed material (e.g. slippery stones vs. small gravel/sand), water depth, and how far out from the bank the employee will be required to go into the stream.

Changing Water Levels

When precipitation falls in the area, water levels within the stream may change quickly. Rising water levels may be dangerous. All personnel should exit the stream once wet weather has occurred in the area. If the forecast calls for rain, the group should meet and discuss

alternative activities that may be planned for the day. After a rain, the SSO must evaluate field conditions and halt field work if there is the possibility of the development of a hazardous condition. When walking in the stream, efforts will be made to walk in the shallow and/or slower moving parts of the stream whenever possible.

3.4.24 Building Collapse

Buildings collapse for a variety of reasons. Natural phenomena such as earthquakes, hurricanes, floods, mudslides, avalanches, and storms are the usual cause for building collapses. Vacant buildings may be at risk for collapse since maintenance-related activities have been often neglected thus resulting in structural damage.

Project personnel should attempt to answer the following questions whenever working near suspect building structures:

- Are there any vacant buildings present on site?
- Will it be necessary to enter or work next to the vacant building(s)?
- Are there any apparent hazards including external damage, falling objects, sticky doors, structural instability, or possible asbestos and/or lead paint?
    - External damage may include, but not necessarily be limited to, foundation cracks, damaged or missing porch roofs and overhangs, supports, gaps between steps and the structure, missing supports or portions of walls, and "washed away" ground.
    - Falling objects may include, but not necessarily be limited to, building cornices, gutters, bricks, and roofs/roofing materials.
- Be aware that when entering a building, if the door sticks at the top it could mean the ceiling is ready to fall. If you force the door open, stand outside the doorway clear of falling debris.
- Has the building(s) been inspected by a qualified professional and deemed safe for entry?
- Are there any viable alternatives for conducting work that preclude the need to enter or work next to the suspect building(s)?

If you have any concerns about entering the building after answering the above questions, speak with the PM immediately. The client will need to be informed that a proper building inspection or engineering controls may be needed before work can be performed.

If you don't feel safe entering a building, notify the PM and RSUM and stay outside the building at an appropriate distance to avoid falling debris.

3.4.25 Removing/Replacing Manhole Covers

Manhole structures are the principal means of access into wastewater collection systems and into other underground utilities and facilities. In general, manhole entries are conducted to determine the physical conditions of manholes and pipelines, collect data, and for maintenance activities.

Removing and replacing manhole covers can present potential hazards (overexertion, struck by, caught between, contaminated air, traffic, etc.) to personnel. Therefore, personnel should always first seek to have client or contractor personnel remove and install the manhole cover whenever possible. If this is not possible, then BC personnel need to plan and carefully consider all the potential hazards and controls associated with the removal and installation. Hard hat, safety glasses, safety boots, and leather/cut-resistant gloves must be used when attempting to remove manhole covers.

When working in the vicinity of an open sewer manhole, air monitoring must be performed to verify that the atmosphere is safe for work activities. At no time are personnel to break the plane of the manhole with any part of their body. Where entry must be made, the requirements of the Confined Spaces section of this HASP must be complied with at all times (i.e. training, air monitoring, ventilation, permitting, rescue, etc.).

General Procedures for Removing/Replacing Manhole Covers

The following are general guidelines for the removal and replacement of manhole covers. Use procedures as they apply to the specific covers to be removed. Additional tools or different procedures may be necessary for a particular location.

Freeing the Manhole Cover

When the cover is stuck in its frame, remove any encrustation with a cold chisel. Next, place a block of wood on the cover near the rim and hit the block of wood with a heavy hammer. Do this at different points around the rim until the cover has loosened.

Unseating the Manhole Cover

Lift the cover with the Hook and Lifter tool. Next, attach the hook and lifter tool to the outer edge/rib before trying to move the cover. Unseat the cover, about four inches, by pulling and lifting with a fluid motion.

Removing the Manhole Cover

Evaluate the area surrounding the manhole cover to be removed and verify conditions that could present a hazard during removal have been properly mitigated. Use proper body mechanics – using the leg and arm muscles to lift and pull the cover – don’t use your back.

With your feet properly positioned evenly apart and footing secure, pull the cover clear of the frame. Once clear of the frame keep pulling the cover with a steady motion and remove it from the work area. Potential pinch points exist to the hands, fingers, and feet. Never place your hands, fingers, or feet under the manhole cover. Whenever possible, have someone assist with the removal and replacement of the manhole cover.

Replacing the Manhole Cover

Stand parallel to the desired direction of travel for moving the manhole and check the cover frame of the manhole to make sure it is free of any obstructions or debris.

Place the point of the Hook and Lifter tool under the edge of the cover, lift slightly, and drag the cover toward its frame.

Move to the opposite side of the cover and repeat the lifting and dragging motion.

Continue alternating the lifting and dragging until the cover is partially over the manhole frame.

With the hook, lift the edge that is farthest from the opening until the cover slides into the frame of the manhole.

Check the cover for proper seating in the manhole cover frame.

3.4.26 Personal Safety - Urban Setting

Working in a distressed neighborhood may present hazards associated with street violence or other crime. In these situations, mental preparation before going to the Site and awareness while on Site are of key importance. If in doubt, always ask Site or client personnel about the safety of a neighborhood. Forethought should be given to arranging to work during daylight hours if possible. Take advantage of any Site security measures (monitoring cameras, security guards) and investigate such measures prior to the field work. Once in the field, work in parties of two or more and stay within view of the general public. Keep a charged cell phone nearby or on your person at all times. Become familiar with your location so you can effectively communicate it over the phone.

In addition to these basic principals, the following is a list of common personal safety rules that apply not only to work at the Site, but to general safety practices while in the field and also between work shifts:

- If at all possible, work/travel in groups. Do not venture out alone.
- Be alert. Notice who passes you and who's behind you. Maintain distance between yourself and strangers. Know where you are, and note potential exit paths.
- If work has paused, do not appear slack or distracted. Do not sit in a vehicle with the doors unlocked.
- Walk in well-lighted areas. Don't walk close to bushes, alleys, and so on. In dark or deserted neighborhoods, walk down the middle of the street (be alert to vehicle traffic).
- If a car pulls up slowly, or the occupants of the vehicle bother you, cross the street and walk or run in the other direction. If you are pursued, dial 911.
- If you feel someone is following you, turn around and check. Proceed to the nearest lighted house or place of business.
- Don't overburden yourself with bags or packages, which might impede running or taking care of yourself.
- Be aware of loose clothing, packs/purses and hair. These give an assailant an easier method of grabbing and controlling you. Wear unrestrictive clothing for ease of movement (but not overly loose).
- Carry a non-weapon personal safety device (such as a whistle, panic button, or key light) - anything that could visually or audibly draw attention to your location.
- What you carry in your hand(s) is important. Valuables make you a potential target. Items such as a hand auger or tool may help you be perceived as a less-than-inviting victim.
- Carry as little cash as possible.
- Hold your purse tightly, close to your body. Keep your wallet in a front or in a buttoned, hip pocket. When at a fixed location, lock your valuable items away and out of site (i.e., in a trunk).
- Be careful when people stop you for directions or information. Always reply from a distance; never get too close to a stranger's car.
- If you feel that you are in danger, don't be afraid to scream and run.
- Toss wallet/keys away from direction of escape.
- Don't attach car keys to house keys.
- Leave large valuables (purse, laptop) locked and hidden in the vehicle.

3.5 Natural Phenomena

Natural phenomena such as weather-related emergencies and acts of nature can affect employees' safety. Natural phenomena can occur with little or no warning. If an emergency situation arises as a result of natural phenomena, adhere to the contingency procedures outlined in Section 10. The following natural phenomena have been identified and may be encountered during scheduled field activities.

☒ Sunburn
☒ Cold Stress
☒ Hurricanes/Nor' Easters
☒ Heat Stress
☒ Lightning/Electrical Storms
☐ Tornados and Strong/Straight Line Winds

☐ Earthquakes ☐ Flooding

3.5.1 Sunburn

Working outdoors with the skin unprotected for extended periods of time can cause sunburn to the skin. Excessive exposure to sunlight is associated with the development of skin cancer. Field staff should take precautions to prevent sunburn by using sunscreen lotion and/or wearing hats and long-sleeved garments.

3.5.2 Heat Stress

Climate conditions, particularly heat, are important considerations in planning and conducting site operations. Heat-related illnesses range from heat fatigue to heat stroke, with heat stroke being the most serious condition. Workers should be trained and aware of signs and symptoms of heat-related illnesses, as well as first aid for these conditions. These are summarized in the table below. The SSO and site workers will monitor each other for signs of heat stress. If an employee exhibits signs or symptoms of heat-related illness, the SSO, or designee, must be notified and the appropriate response procedures initiated.

Heat Related Illness

Condition	Signs	Symptoms	Response
Heat Rash or Prickly Heat	Red rash on skin.	Intense itching and inflammation.	Increase fluid intake and observe affected worker.
Heat Cramps	Heavy sweating, lack of muscle coordination.	Muscle spasms, and pain in hands, feet, or abdomen.	Increase fluid uptake and rest periods. Closely observe affected worker for more serious symptoms.
Heat Exhaustion	Heavy sweating; pale, cool, moist skin; lack of coordination; fainting.	Weakness, headache, dizziness, nausea.	Remove worker to a cool, shady area. Administer fluids and allow worker to rest until fully recovered. Increase rest periods and closely observe worker for additional signs of heat exhaustion. If symptoms of heat exhaustion recur, treat as above and release worker from the day's activities after he/she has fully recovered.
Heat Stroke	Red, hot, dry skin; disorientation; unconsciousness	Lack of or reduced perspiration; nausea; dizziness and confusion; strong, rapid pulse.	Immediately contact emergency medical services by dialing emergency medical services. Remove the victim to a cool, shady location and observe for signs of shock. Attempt to comfort and cool the victim by administering small amounts of cool water (if conscious), loosening clothing, and placing cool compresses at locations where major arteries occur close to the body's surface (neck, underarms, and groin areas). Carefully follow instructions given by emergency medical services until help arrives.

The effects of ambient temperature can cause physical discomfort, loss of efficiency, and personal injury, and can increase the probability of mishaps. In particular, protective clothing that decreases the body's ventilation can be an important factor leading to heat-related illnesses.

To reduce the potential for heat-related illness, workers are encouraged to drink plenty of water/fluids to stay properly hydrated. in addition, a work schedule will be established that will provide sufficient rest periods for cooling down (at least five minutes when workers feel the need to do so) and have access to shade from the sun (which, in addition to natural shade or canopies, includes resting inside a vehicle with the air conditioner running). Personnel must maintain an adequate supply of non-caffeinated drinking fluids on site for personal hydration – a minimum of one quart of water per employee per hour.

3.5.3 Cold Stress

Workers performing activities during winter and spring months may encounter extremely cold temperatures, as well as conditions of snow and ice, making activities in the field difficult. Adequate cold weather gear, especially head and foot wear, is required under these conditions. Workers should be aware of signs and symptoms of hypothermia and frostbite, as well as first aid for these conditions. These are summarized in the table below.

Cold Stress Symptoms and Response

Condition	Signs	Symptoms	Response
Hypothermia	Confusion, slurred speech, slow movement.	Sleepiness, confusion, warm feeling.	Remove subject to a non-exposed, warm area, such as truck cab; give warm fluids; warm body core; remove outer and wet clothing and wrap torso in blankets with hot water bottle or other heat source. Get medical attention immediately.
Frostbite	Reddish area on skin, frozen skin.	Numbness or lack of feeling on exposed skin.	Place affected extremity in warm, not hot, water, or wrap in warm towels. Get medical attention.
Trench Foot	Swelling and/or blisters of the feet	Tingling/itching sensation; burning; pain in the feet	Remove wet/constrictive clothing and shoes. Gently dry and warm feet with slight elevation. Seek medical attention.

3.5.4 Lightning/Electrical Storms

Lightning can be unpredictable and may strike many miles in front of, or behind, a thunderstorm. Workers will therefore cease field operations at the first sign of a thunderstorm and suspend activities until at least 30 minutes after the last observed occurrence of lightning or thunder. For purposes of this HASP, signs of a thunderstorm will include any visible lightning or audible thunder.

In the event of a thunderstorm, field personnel will take the following actions:

- Get inside a permanent building structure (not a shed or canopy) or fully enclosed metal vehicle (not a convertible or camper shell) with the windows fully up.
- If in a house or building, do not use the telephone or any electrical appliance that's connected to the building's electrical wiring.
- Stay away from tall isolated objects, such as trees, drill rigs, telephone poles, or flag poles.
- Avoid large open areas, such as fields or parking lots, where a person is the relatively highest object.
- Stay away from lakes, ponds, railroad tracks, fences, and other objects that could transmit current from a distant lightning strike.
- If caught out in the open without time to escape or find shelter, seek a low area (if time permits), crouch down, and bend forward holding the ankles. Tuck the head so that it's not the highest part of the body, without letting it touch the ground. Under no circumstances lay down.

If a person is struck by lightning contact emergency medical services, even if he/she appears only stunned or otherwise unhurt as medical attention may still be needed. Check for burns, especially at fingers and toes, and areas next to buckles and jewelry.

3.5.5 Hurricanes/Nor' Easters

The key to responding to hurricane conditions is being informed. Before taking to the roads to leave for or from a jobsite during suspect hurricane conditions, listen to the radio for current and forecast conditions. Know what the weather reports mean by "watch" and "warning." A hurricane watch means hurricane conditions are possible in the specified area of the watch, usually within 36 hours. A hurricane warning indicates hurricane conditions are expected in the specified area of the warning, usually within 24 hours.

If watch or warning conditions exist, employees will communicate with the project manager to determine the appropriate course of action. Travel to or from work is not recommended if the employee will travel in the vicinity of a hurricane warning area. Restrictions on travel during hurricane watches are largely dependent on the actual weather conditions at the time. Employees are discouraged from driving during weather conditions where visibility and vehicle control are severely limited.

Nor'easters have the potential to cause as much damage as hurricanes, with powerful winds, rain or snow and large waves. They can pound and erode beaches with heavy surf, affect inland areas with flooding, or coat the land with thick layers of ice and snow.

Nor’easters result from the counterclockwise rotation of a low pressure system and the clockwise rotation of a high pressure system, combining to bring wind and moisture to the northeast. The nor'easter's ferocity will depend on the strength of the two systems.

One reason nor’easters are so dangerous is that they tend to move much more slowly than hurricanes. That slow movement allows the storm’s effects to accumulate in a given area.

A nor’easter’s wind circulation can cause tidal waters in back bays to be held in place, and not allow the water to drain through inlets and into the ocean. The accumulation of more and more water in tidal areas can cause widespread flooding.

Nor'easters can occur all year long, but are primarily a risk between September and April.

In the event of a hurricane or nor’ easter, be prepared by:

- Checking NOAA Weather Radio All Hazards, your local radio and TV stations (i.e, The Weather Channel) for updates, watches, warnings or emergency instructions.
- Know the Coastal Evacuation Route for coastal areas or an inland area with chronic flooding.

For long term projects with temporary or permanent office area, keep an emergency preparedness kit consisting of, but not limited to:

- Current project/office contacts list – (how to reach folks in an emergency),
- Blankets,
- Flashlights,
- Radio (operated by batteries),
- Batteries for flashlight and radio (note: batteries should be replaced annually to assure freshness) ,
- Water (unless there is a water bubbler that can be used with no electricity), and
- Snack crackers, dried fruit, etc. - a source of food that won't go bad.

3.5.6 Tornados and Strong/Straight Line Winds

Tornados and strong or straight line winds are potentially dangerous weather conditions because both have the ability to generate on very short notice (in some cases under one hour from clear weather conditions). Tornados and strong or straight line winds both have the same warning properties and recommendations. If a tornado “watch” is issued for your area, it means that a tornado is “possible”. If a tornado “warning” is issued, it means that a tornado has actually been spotted, or is strongly indicated on radar, and it is time to go to a safe shelter immediately.

Be alert to what is happening outside, but do not place yourself in jeopardy by standing next to windows. Some common observations during a tornado include: a sickly greenish or greenish-black color to the sky; if there is a watch or warning announced or posted; an abrupt fall of hail (however, hail can occur in the absence of a tornado); a strange quiet that occurs within or shortly after a thunderstorm; clouds moving by very fast, especially in a rotating pattern or converging toward one area of the sky; a sound like a waterfall or rushing air at first, but turning into a roar as it comes closer (the sound of a tornado has been likened to that of both railroad trains and jets); debris dropping from the sky; an obvious “funnel-shaped” cloud that is rotating; or debris such as branches or leaves being pulled upwards, even if no funnel cloud is visible.

During a tornado warning or tornado occurrence, each employee is instructed to do the following:

- Proceed to interior rooms and halls on the lowest floor (do not use an elevator to exit an upper floor). Avoid halls that open to the outside in any direction. If there are no interior hallways, avoid those that open to the southwest, south, or west, since that is usually the direction from which the tornado will come.
- Stay away from glass, both windows and doors. Crouch down, and make as small a “target” as possible. If you have something with which to cover your head, do so, otherwise, use your hands.
- Exercise extreme caution when leaving your area of shelter. Be aware of potential hazards (i.e., natural gas smell, smoke, fire). In the event these hazards are encountered in your area of shelter, immediately evacuate the shelter. If the building/shelter has been damaged by a tornado, do not flush the toilets, as the sewer lines may have been damaged.
- If you are traveling in an automobile and can see a tornado, do not stay in your car and try to outrun a tornado. If possible, stop the car and enter the nearest business and seek shelter.
- If you are outside and it is not possible to get inside, seek a low lying ditch, culvert, etc. and keep your body as low to the ground and as braced as possible.

3.5.7 Earthquakes

Earthquakes strike suddenly, violently, and without warning. If your project is located near a fault line, earthquakes are an unpredictable possibility. For long term projects with temporary or permanent office area, keep an emergency preparedness kit consisting of, but not limited to:

- Current project/office contacts list - how to reach folks in an emergency,
- Blankets,
- Flashlights,
- Radio (operated by batteries),
- Batteries for flashlight and radio (note: batteries should be replaced as needed to assure freshness),
- Water (unless there is a water bubbler that can be used with no electricity), and
- Snack crackers, dried fruit, etc. - a source of food that won't go bad.

This kit is meant to serve as overnight survival in the event that it becomes unsafe to leave the project site. The kit's contents should be suited to meet the size and needs of your project. If you feel the earth shaking, consider the following tips:

- Drop down; take cover under a desk or table and hold on.
- Stay indoors until the shaking stops and you are sure it is safe to exit.
- Stay away from bookcases, shelves, or anything that could fall on you.
- Stay away from windows.
- If inside a building, expect fire alarms and sprinklers to go off during the quake.

- If you are outdoors, find a clear spot away from buildings, trees, and power lines. Drop to the ground and cover your head.
- If you are in a car, slow down and drive to a clear place, preferably away from power lines. Stay in the car until the shaking stops.

3.5.8 Flooding

Flooding may occur at or en-route to and from the Site and may be the result of weather conditions or due to thawing of ice and snow (especially in the Spring).

In the event flooding starts to occur:

- Stay tuned to NOAA Weather Radio All Hazards, your local radio and TV stations (i.e., The Weather Channel) for updates, watches, warnings or emergency instructions.
- Know the Coastal Evacuation Route for coastal area or an inland area with chronic flooding
- If the waters start to rise inside before you have evacuated, retreat to higher ground, including the roof. Use cell phone or land line to call for help. Take a flashlight and a portable radio. Then, wait for help. Don't try to swim to safety; wait for rescuers to come to you.
- Avoid flooded areas. Do not attempt to cross any flooded areas in a vehicle or on foot. Flood waters may be deeper than they look.
- Avoid low-lying areas like ditches, creeks, and rivers.
- Before entering or re-entering a building, check for any signs of structural damage.
- When entering a building, do not use matches, lighters, or open flame. Use a flashlight only.
- After a flood, steps and floors are often slippery with mud and covered with debris, including nails and broken glass. Be careful walking around.

3.6 Biological Hazards

The following biological hazards have been identified and may be encountered during scheduled field activities.

☐ Bloodborne Pathogens/Sanitary Waste
☒ Reptiles/Snakes
☒ Mosquitoes
☒ Spiders/Scorpions
☒ Poisonous Plants
☒ Rodents and Mammals
☒ Venomous Insects
☐ Fire Ants
☒ Ticks

If any biological hazards are identified at the Site, workers in the area will immediately notify the SSO and nearby personnel.

3.6.1 Bloodborne Pathogens/Sanitary Waste

Potential exposure to bloodborne pathogens may occur during some work activities (e.g., sewer video surveys or source sampling), rendering first aid or CPR. Direct contact is an important route of exposure for bloodborne pathogens due to puncture injuries, contact with abraded skin, or contact with areas such as the eyes, without appropriate protection. While very few organisms can enter the body through normal intact skin, direct contact with sewage, blood and body fluids is to be avoided. Site personnel should thoroughly wash their hands and face before eating, drinking or smoking and before leaving the work site.

Exposure controls and Universal Precautions are required at suspect locations, in order to prevent contact with blood or other potentially infectious materials as specified in Brown and Caldwell's Bloodborne Pathogens Program. All blood or other potentially infectious material will be considered infectious regardless of the perceived status of the source individual. A Hepatitis B vaccination will be offered to BC personnel before the person participates in a task where direct exposure to potentially infectious materials is a possibility (i.e., first aid or CPR). For personnel who have potential exposure to sanitary wastes, a current tetanus/diphtheria inoculation or booster is recommended.

3.6.2 Rodents/Mammals

Animals may potentially carry the rabies virus or disease causing agents. Do not attempt to feed or touch animals. Feces from some small mammals may contain diseases such as Hanta Virus. Avoid generating dust in the vicinity of rodent feces. In addition, animals such as dogs or wild predators (i.e., cougars or coyotes) may pose an attack hazard. Persons should slowly back away in a non-threatening manner if an encounter with a threatening animal occurs. In order to avoid such encounters, use the buddy system and make noise when working in areas where such animals may be present.

3.6.3 Reptiles/Snakes

The primary reptiles of concern are venomous snakes (rattlesnake, water moccasin, and copperhead). Avoid contact and areas that may harbor snake populations including high grass, shrubs, and crevices. In the event of a bite, immobilize the affected area and contact emergency medical services. If more than 30 minutes from emergency care, apply bandage wrap two to four inches above the bite (note: bandage should be loose enough to slip your finger underneath).

Wear shoes and heavy pants when walking and hiking in areas where snakes are likely found. Do not reach into rocky cracks, under logs, or large rocks. Even if a snake looks dead, do not touch it. A snake can still bite up to one hour after its death. Do not get near or tease a snake. Snakes are shy creatures and generally will not attack unless bothered.

Diamond Back Rattle Snake

Diamond backs are large snakes. They have a row of dark diamonds down the back and a rattle on their tail. These snakes have cat-like eyes and a pit between their nostril and eye. Eastern diamond backs like pine flat woods and scrub areas where palmetto thickets and gopher tortoise burrows are found. These snakes travel during the day and hide at night.

Timber Rattle Snake

Timber rattle snakes have a reddish-brown stripe running down the center of their back and black cross bands. Their tails are solid black with a rattle. These snakes have cat-like eyes and a pit between their nostril and eye. Timber rattlers live in damp river beds, pine flat woods, swamps, and cane thickets.

Pygmy Rattle Snake

These small snakes are light to dark grey in color. They have a tiny rattle. Pygmy rattle snakes have cat-like eyes and a pit between their nostril and eye. These snakes are found in lowland pine flat woods, prairies, around lakes, ponds, and swamps. Pygmy rattlers are aggressive and will strike anything within striking range.

Cottonmouth (Water Moccasin)

Young cottonmouths are often mistaken for copperheads because of their reddish-brown cross bands. As these snakes age, their cross bands darken until they become almost solid black. Cottonmouths live near water sources like lakes, streams, rivers, ponds, and swamps. When threatened, cottonmouths may coil and open their mouths as though ready to bite. The white inside of the mouth is what gives this snake its name, "cottonmouth".

Copperhead

Copperheads have dark coppery red-brown hourglass cross bands on a lighter brown color. The top of the head is covered with large plate-like scales. Copperheads have cat-like eyes and a pit between their nostril and eye. These snakes live in rocky, wooded areas and low, wet swampy areas. Copperheads are sluggish and rarely bite, unless stepped on or touched.

Coral Snake

The body of this snake is ringed with black, yellow and red bands. (Remember: Red on yellow can kill a fellow. Red on black, venom lack.) The head of a coral snake is black, while the tail is black and yellow.

3.6.4 Venomous Insects

Common examples include bees, fire ants and wasps. Avoid contact with insects and their hives. If stung, remove the stinger by gently scraping it out of the skin (do not use tweezers). If the worker is stung by an insect, immediately apply an ice pack to the affected area and wash area with soap and water and apply antiseptic. If an allergic reaction occurs, contact emergency medical services for appropriate treatment. Seek medical attention immediately if you are allergic to venomous stings such as bees or if anaphylaxis symptoms are present.

3.6.5 Mosquitoes

Mosquitoes may transmit diseases such as West Nile Virus. Symptoms of West Nile Virus include: fever, headache, tiredness, body aches, and occasional rash. Avoid mosquito bites by wearing long sleeved shirt and long pants. Apply insect repellent to clothes and/or skin (if FDA approved for topical use). Report any dead birds in the area to local health officials. Mosquitoes are most active from dusk to dawn.

3.6.6 Fire Ants

Red and Black Fire Ants are capable of inflicting numerous stings (7 to 9) per ant in a matter of seconds, and large numbers of fire ants will typically attack at the same time. Fire ants are very aggressive and will sting simply upon coming in contact with skin. Individuals who are allergic to bees should carry bee sting kits when there is the potential to come in contact with fire ants. Fire ants are predominantly located in the southern United States.

The best way to avoid fire ants is to avoid disturbing their mounds. Fire ant mounds are typically constructed in disturbed habitats such as open fields, along roadsides, lawns, and many other open sunny areas. The mounds are constructed of dirt and/or other organic materials. Mounds are typically 10” to 24” in diameter and approximately 18” in height. If you disturb a mound, get away from the mound immediately.

Fire ant stings typically leave tiny red blisters and sometimes white pustules. Symptoms of stings include blistering, burning, swelling, pain, and irritation of the affected area. Recommended treatment consists of antihistamines along with topical antibiotic cream. Anaphylaxis symptoms such as shortness of breath, discomfort, lowered heart rate, etc. may also accompany fire ant stings. Seek medical attention immediately if you are allergic to venomous stings such as bees or if anaphylaxis symptoms are present.

3.6.7 Spiders/Scorpions

The black widow and brown recluse spiders are the most venomous. Avoid contact with spiders and scorpions and areas where they may hide. They favor dark hiding places. Inspect clothing and shoes before getting dressed. Wear gloves and safety shoes when working with lumber, rocks, inspecting buildings, etc. Signs and symptoms of bites include: headache, cramping pain/muscle rigidity, rash and/or itching, nausea, dizziness, vomiting, weakness or paralysis, and convulsions or shock. Wash bite area with soap and water and apply antibiotic cream. Contact emergency medical services if allergic reaction or severe symptoms occur.

3.6.8 Ticks

Deer ticks may carry and transmit Lyme disease to humans. Signs of Lyme disease include a reddish “bulls-eye” around the affected area approximately a week after the bite. Symptoms include headache, fever, and muscle/joint pain. Persons suspecting infection should contact a health professional. Whenever possible, avoid areas likely to be infested with ticks during the spring and summer months.

Wear light-colored clothing so ticks can be easily spotted and removed. Wear long sleeves and pants and tuck pant legs into boots or socks. Apply insect repellents to clothing and skin (if FDA approved for topical application). Persons with long hair should tie their hair back to minimize the potential for ticks to nestle in the scalp.

Personnel should self perform tick checks once daily field work is completed. If a tick is embedded in the skin, use tweezers to grasp the tick’s head (near the skin) and pull straight out. Consider saving the removed tick for laboratory analysis.

3.6.9 Poisonous Plants

Common examples include poison ivy, poison oak and poison sumac. Avoid contact. Long-sleeved shirts and pants will allow some protection against inadvertent contact. If contact occurs, immediately wash the affected area thoroughly with soap and water. If an allergic reaction occurs, seek the care of a medical professional.

<u>Poison Ivy</u> is a trailing or climbing woody vine or a shrub-like plant with leaves that are each divided into three broad, pointed leaflets. The leaflets are commonly dark glossy green on top and slightly hairy underneath. They produce small yellowish or greenish flowers followed by berry-like drupes.

<u>Poison Oak</u> is a member of the same family as poison ivy and has a very similar appearance. Poison oak has leaves divided into three leaflets and generally has three to seven distinct lobes. Typically they are a shrubby type plant that can grow to eight feet in height, or sometimes can be a climbing plant.

The best way to prevent exposure is the ability to recognize these plants. Conduct an initial survey of the area to determine if the plants are present in the work area, and avoid contact with them.

If plants are located and work must be conducted in that area, have the plants removed if possible. If this is not possible, wear long sleeved shirts, gloves, and a heavy material type pants. Remember not to touch contaminated clothing. There are products available that can be applied to exposed skin, (similar to sunscreen products) prior to working around the plants. Tyvek suits may be another option used at the wearer's discretion to keep poisonous plant oils from getting on clothing. Please note that using Tyvek suits may increase the risk of heat stress conditions so extra precautions should be taken such as more frequent breaks and drinking plenty of fluids

Section 4

Personal Protective Equipment

The purpose of PPE is to protect employees from hazards and potential hazards they are likely to encounter during site activities. The amount and type of PPE used will be based on the nature of the hazard encountered or anticipated. Respiratory protection will be utilized when an airborne hazard has been identified using real-time air monitoring devices, or as a precautionary measure in areas designated by the RSUM or SSO.

Dermal protection, primarily in the form of chemical-resistant gloves and coveralls, will be worn whenever contact with chemically affected materials (e.g., soil, groundwater, sludge) is anticipated, without regard to the level of respiratory protection required.

On the basis of the hazards identified for this project, the following levels of personal protective equipment (PPE) will be required and used. Changes to the specified levels of PPE will not be made without the approval of the SSO after consultation with the RSUM.

4.1 Conditions Requiring Level D Protection

In general, site activities will commence in Level D PPE unless otherwise specified, or if the SSO determines on site that a higher level of PPE is required. Air monitoring of employee breathing zones will be routinely conducted using real-time air monitoring devices to determine if upgrading to Level C PPE is necessary. Level D PPE will be permitted as long as air monitoring data indicate that airborne concentrations of chemicals of concern are maintained below the site-specific action levels defined in Section 5.2. Level A or B PPE is not anticipated and is therefore not addressed in this plan. If Level A or B PPE is necessary, this HASP will be revised to reflect changes as appropriate.

It is important to note that dermal protection is required whenever contact with chemically-affected materials is anticipated. The following equipment is specified as the minimum PPE required to conduct activities at the Site:

- Work shirt and long pants,
- ANSI- or ASTM-approved steel-toed boots or safety shoes,
- ANSI-approved safety glasses, and
- ANSI-approved hard hat (where required on-site or when overhead hazards are present);
- Outer nitrile gloves (11 mil or thicker) and inner nitrile surgical gloves when direct contact with chemically affected soils or groundwater is anticipated (nitrile surgical gloves may be used for collecting or classifying samples as long as they are removed and disposed of immediately after each sampling event).
- Sturdy work gloves.
- High-visibility traffic safety vest.

Other personal protection readily available for use, if necessary, includes the following items.

- Chemical goggles when in contact with chemical liquids can be reasonably expected or when handling corrosive chemicals. In addition, a face shield may be required to protect the face from splash hazards.

- Chemical-resistant clothing (e.g., Tyvek or polycoated Tyvek coveralls) when contact with chemically affected soils or groundwater is anticipated.
- Safety shoes/boots with protective overboots or knee-high PVC polyblend boots when direct contact with chemically affected soils is anticipated.
- Hearing protection.

Work will cease and PPE upgraded if action levels specified in Section 5.2 are exceeded. The RSUM will be notified whenever PPE is upgraded or downgraded.

4.2 Conditions Requiring Level C Protection

If air monitoring indicates that the site-specific action levels defined in Section 5.2 are exceeded, workers in the affected area(s) will upgrade PPE to Level C. In addition to the protective equipment specified for Level D, Level C also includes the following items.

- NIOSH-approved half- or full-face air-purifying respirator (APR) equipped with appropriate cartridges (reference Section 5.2). Note: safety glasses are not required when wearing a full-face APR.

Respirators will be stored in clean containers (i.e., self-sealing bag) when not in use. Respirator cartridges will be replaced in accordance with the following change-out schedule.

Respirator Cartridge Replacement

Type of Cartridge	Cartridge Change-out Schedule
Particulate (i.e., HEPA)	At least weekly or sooner the employee detects an increase in breathing resistance. This will occur as the filter becomes loaded with particulate matter.
Sorbent (i.e., organic vapor)	At the end of each day's use or sooner if the employee detects an abnormal odor or other indicator.

Personnel who wear air-purifying respirators must be trained in their use and must have successfully passed either a qualitative or quantitative respirator fit test, and medical evaluation within the last 12 months in accordance with and 29 CFR 1910.134.

4.3 Stop Work Conditions

If air monitoring indicates that the site-specific action levels defined in Section 5.2 are exceeded, activities will cease, and personnel must evacuate the designated Exclusion Zone. The PM and RSUM will be contacted immediately.

Work will also cease if unanticipated conditions or materials are encountered or if an imminent danger is identified. The SSO will immediately contact the RSUM for consultation.

Section 5

Air Monitoring Plan

Real-time air monitoring devices will be used to analyze airborne contaminant concentrations approximately every 15 minutes in the workers' breathing zones while workers are in the designated Exclusion Zone, or when task or exposure conditions change (whichever frequency is less). If elevated concentrations are indicated, the monitoring frequency will be increased, as appropriate.

Background concentrations will be determined at the beginning of each work shift by collecting several instrument readings upwind of the scheduled activities. Alternatively, background levels can be determined by collecting readings from a nearby (upwind) area that can reasonably be considered unaffected by Site activities.

Real-time measurements will be made as near as feasible to the breathing zone of the worker with the greatest exposure potential in each active work area. If authorized by the RSUM, real time measurements may cease being taken when sufficient historical data is generated to warrant its cessation. Air monitoring will be reinstated if potential exposure conditions change.

The equipment will be calibrated daily, and the results will be recorded on BC's Air Monitoring Form. The results of air monitoring will also be recorded on the Air Monitoring Form and will be retained in the project files following completion of field activities. A copy of the Air Monitoring Form is located in Appendix A.

5.1 Monitoring Instruments

On-site worker exposure to airborne contaminants will be monitored during intrusive site activities.

5.1.1 Photoionization Detector and Flame ionization Detector

A calibrated photoionization detector (PID) and/or flame ionization detector (FID) will be used to monitor changes in personnel exposure to volatile organic compounds (VOCs). The appropriate combination of equipment is either a MiniRae 3000 with an 11.7eV lamp and a ppbRAE with a 10.6 lamp or the TVA 1000 FID/PID combination (which contains a 10.6 eV lamp PID and FID). The SSO, or designee, will perform routine monitoring during site operations to evaluate concentrations of VOCs in employee breathing zones. If VOCs are detected above predetermined action levels specified in Section 5.2, the procedures found in Section 4 of this HASP will be followed.

5.1.2 Colorimetric Tubes

A hand-held Draeger pump along with Benzene colorimetric Draeger tubes will be used to monitor for the presence of benzene per the action levels specified in the tables below.

5.2 Site Specific Action Levels

The following action levels were developed for exposure monitoring with real-time air monitoring instruments. Air monitoring data will determine the required respiratory protection levels at the Site during scheduled intrusive activities. The action levels are based on sustained readings indicated by the instrument(s). Air monitoring will be performed and recorded at up to 15-minute intervals.

If elevated concentrations are indicated, the monitoring frequency will be increased, as appropriate. If during this time, sustained measurements are observed, the following actions will be instituted, and the PM and RSUM will be notified. For purposes of this HASP, sustained readings are defined as the average airborne concentration maintained for a period of one (1) minute above established background levels.

5.2.1 Action Levels for Volatile Organic Compounds

Draeger tubes will be used to determine the presence or absence of benzene when PID/FID readings exceed 1 ppm.

VOC – Action Levels		
Activity	**Action Level**	**Level of Respiratory Protection**
PDI Activities	< 5 ppm above background (**no benzene indicated**)	Level D: No respiratory protection required. **Note**: For PID/FID values above 1 ppm, benzene is to be analyzed for with a colorimetric tube.
	5 to 25 ppm above background (**no benzene indicated**) or **Benzene indicated** < 1.0 ppm (colorimetric tube)	Level C: Half- or full-face air-purifying respirator fitted with organic vapor cartridges: Increase engineering control efforts and re-monitor effectiveness. **Note**: For PID/FID values above 1 ppm, benzene is to be analyzed for with a colorimetric tube. **Contact Director and RSUM prior to respirator upgrade**.
	> 25 ppm above background (**no benzene indicated**) or **Benzene indicated** > 1.0 ppm (colorimetric tube)	Cease operations and evacuate work area. Contact **Director and RSUM and PM** immediately.

Section 6

Site Control Measures

The SSO will conduct a safety inspection of the work site before each day's activities begin to verify compliance with the requirements of the HASP. Results of the first day's inspection will be documented on the Site Safety Checklist. A copy of the checklist is included in Appendix B. Thereafter, the SSO should document unsafe conditions or acts, along with corrective action, in the project notes or field log book.

Procedures must be followed to maintain site control so that persons who may be unaware of site conditions are not exposed to hazards. The work area will be barricaded by tape, warning signs, or other appropriate means. Site equipment or machinery will be secured and stored safely.

Access to the specified work area will be limited to authorized personnel. Only BC employees and designated BC subcontracted personnel, as well as designated employees of the client, will be admitted to the work site. Personnel entering the work area are required to sign the signature page of this HASP, indicating they have read and accepted the health and safety practices outlined in this plan.

In some instances it may be necessary to define established work zones: an Exclusion Zone, a Contamination Reduction Zone, and a Support Zone. Work zones may be established based on the extent of anticipated contamination, projected work activities, and the presence or absence of non-project personnel. The physical dimensions and applicability of work zones will be determined for each area based on the nature of job activity and hazards present. Within these zones, prescribed operations will commence using appropriate PPE. Movement between zones will be controlled at checkpoints.

Considerable judgment is needed to maintain a safe working area for each zone, balanced against practical work considerations. Physical and topographical barriers may constrain ideal locations. Field measurements combined with climatic conditions may, in part, determine the control zone distances. Even when work is performed in an area that does not require the use of chemical-resistant clothing, work zone procedures may still be necessary to limit the movement of personnel and retain adequate site control.

Personnel entering the designated Exclusion Zone should exit at the same location. There must be an alternate exit established for emergency situations. In all instances, worker safety will take precedence over decontamination procedures. If decontamination of personnel is necessary, exiting the Site will include the decontamination procedures described in the following section.

Section 7

Decontamination Procedures

Decontamination will take place in the decontamination area identified on-Site. Workers, PPE, sampling equipment, and heavy equipment leaving the exclusion area will be inspected to determine the level of decontamination necessary to prevent the spread of potentially hazardous materials. Unnecessary equipment and support vehicles are to be left outside the designated Exclusion Zone so that decontamination will not be necessary.

Despite protective procedures, personnel may come in contact with potentially hazardous compounds while performing work tasks. If so, decontamination needs to take place using an Alconox or TSP wash, followed by a rinse with clean water. Standard decontamination procedures for levels C and D are as follows.

- equipment drop,
- boot cover and outer glove wash and rinse,
- boot cover and outer glove removal,
- suit removal,
- safety boot wash and rinse,
- inner glove wash and rinse,
- respirator removal,
- inner glove removal, and
- field wash of hands and face.

Site workers should employ only applicable steps in accordance with level of PPE worn and extent of contamination present. The SSO shall maintain adequate quantities of clean water to be used for personal decontamination (i.e., field wash of hands and face) whenever a suitable washing facility is not located in the immediate vicinity of the work area.

Disposable items will be disposed of in an appropriate container. Wash and rinse water generated from decontamination activities will be handled and disposed of properly. Non-disposable items (i.e., respirators) may need to be cleaned or sanitized before reuse. Each site worker is responsible for the maintenance, decontamination, and sanitizing of their own PPE.

Used equipment may be decontaminated as follows.

- Remove adhered materials (i.e., dirt or mud) to increase the effectiveness of the decontamination process.
- An Alconox or TSP and water solution may be used to wash the equipment.
- The equipment will then be rinsed with clean water until it is determined clean.

Each person must follow these procedures to reduce the potential for transferring chemically affected materials off site.

Section 8

Training Requirements

BC Site personnel, including subcontractors and visitors conducting work in controlled areas of the Site, must have completed the appropriate training as required by 29 CFR 1910.120. In addition, the SSO will have completed the 8-hour Site Supervisor course, have current training in first aid and CPR, and any additional training appropriate to the level of site hazards. Further site-specific training will be conducted by the SSO prior to the initiation of project activities. This training will include, but will not necessarily be limited to, emergency procedures, site control, personnel responsibilities, and the provisions of this HASP. Each employee will document that they have been briefed on the hazards identified at the site and that they have read and understand the requirements of this HASP by signing the H&S Plan Acknowledgement Form attached as Appendix C.

A daily morning briefing to cover safety procedures and contingency plans in the event of an emergency is to be included with a discussion of the day's activities. These daily meetings will be recorded on the Daily Tailgate Safety Meeting Form. A copy of the Daily Tailgate Safety Meeting Form is included in Appendix D.

<u>Exception:</u> When there is only one employee performing field activities for the project, a formal and documented daily tailgate safety meeting (or completion of the form) is not required. However, personnel are still expected to plan their work activities and attend any site specific safety meetings or training so that tasks are performed safely.

Section 9

Medical Surveillance Requirements

BC Site personnel, including subcontractors and site visitors, who will or may work in an area designated as an exclusion zone must have fulfilled the appropriate medical monitoring requirements in accordance with 29 CFR 1910.120(f). Each individual entering an exclusion zone must have successfully completed an annual surveillance examination and/or an initial baseline examination within the last 12 months.

Medical surveillance is conducted as a routine program for BC field staff in accordance with the requirements of 29 CFR 1910.120(f). There will not be any special medical tests or examinations required for staff involved in this project.

A Hepatitis B vaccination will be offered to BC personnel before the person participates in a task where direct exposure to potentially infectious materials is a possibility (i.e., first aid or CPR). For personnel who have potential exposure to sanitary wastes, a current tetanus/diphtheria inoculation or booster is recommended.

Section 10

Contingency Procedures

Minimum emergency equipment maintained on site will include a fully charged ABC dry chemical fire extinguisher, an adequately stocked first aid kit, and an emergency eyewash station (when corrosive chemicals are present). In addition, employees will consider maintaining the personal emergency supply items listed in Section 3: Natural Phenomena, as appropriate.

In the event of an emergency, site personnel will signal distress with three blasts of a horn (a vehicle horn will be sufficient), or other predetermined signal. Communication signals, such as hand signals, must be established where communication equipment is not feasible or in areas of loud noise.

It is the SSO's duty to evaluate the seriousness of the situation and to notify appropriate authorities. The first part of this plan contains emergency telephone numbers as well as directions to the hospital. Nearby telephone access must be identified and available to communicate with local authorities. If a nearby telephone is not available, a cellular telephone will be maintained on site during work activities. The operation of the cellular phone will be verified to confirm that a signal can be achieved at the work location.

The SSO, or designee, should contact local emergency services in the event of an emergency. After emergency services are notified, the PM and RSUM will be notified of the situation as soon as possible. If personal injury, property damage or equipment damage occurs, the PM and BC Risk Manager will be contacted as soon as practicable. An Incident Investigation Report will be completed within 24 hours by the SSO, or other designated person. A copy of the Incident Investigation Report is included in Appendix E.

10.1 Injury or Illness

If an exposure or injury occurs, work will be temporarily halted until an assessment can be made to determine it is safe to continue work. The SSO, in consultation with the RSUM, will make the decision regarding the safety of continuing work. The SSO will conduct an investigation to determine the cause of the incident and steps to be taken to prevent recurrence.

In the event of an injury, the extent and nature of the victim's injuries will be assessed and first aid/CPR will be rendered as appropriate. If necessary, emergency services will be contacted or the individual may be transported to the nearby medical center. The mode of transportation and the eventual destination will be based on the nature and extent of the injury. A hospital route map is presented at the front of this HASP.

In the event of a life-threatening emergency, the injured person will be given immediate first aid and emergency medical services will be contacted by dialing the number listed in the Critical Project Information section at the beginning of this plan. The individual rendering first aid will follow directions given by emergency medical personnel via telephone.

10.2 Vehicle Collision or Property Damage

If a vehicle collision or property damage event occurs, the SSO, or designee, will contact the BC Risk Manager for appropriate action.

10.3 Fire

In the event of fire, the alarm will be sounded and Site personnel will evacuate to a safe location (preferably upwind). The SSO, or designee, should contact the local fire department immediately by dialing 911. When the fire department arrives, the SSO, or designated representative, will advise the commanding officer of the location and nature of the fire, and identification of hazardous materials on site. Only trained, experienced fire fighters should attempt to extinguish substantial fires at the Site. Site personnel should not attempt to fight fires, unless properly trained and equipped to do so. Site personnel should not attempt to fight a fire if it poses a risk to their personal safety.

Note that smoking is not permitted in controlled areas (i.e., exclusion or contamination reduction zones), near flammable or combustible materials, or in areas designated by the facility as non-smoking areas.

10.4 Underground Utilities

In the event that an underground conduit is damaged during subsurface work, mechanized equipment will immediately be shut off and personnel will evacuate the area until the nature of the piping can be determined. Depending on the nature of the broken conduit (e.g., natural gas, water, or electricity), the appropriate local utility will be contacted.

10.5 Site Evacuation

The SSO will designate evacuation routes and refuge areas to be used in the event of a Site emergency. Site personnel will stay upwind from vapors or smoke and upgradient from spills. If workers are in an Exclusion or Contamination Reduction Zone at the start of an emergency, they should exit through the established decontamination corridors, if possible. If evacuation cannot be done through an established decontamination area, site personnel will go to the nearest safe location and remove chemically-affected clothing there or, if possible, leave it near the Exclusion Zone. Personnel will assemble at the predetermined refuge following evacuation and decontamination. The SSO, or designated representative, will count and identify site personnel to verify that all have been evacuated safely.

10.6 Spill of Hazardous Materials

If a hazardous material spill occurs, site personnel should locate the source of the spill and determine the hazard to the health and safety of site workers and the public. Attempts to stop or reduce the flow should only be performed if it can be done without risk to personnel.

Isolate the spill area and do not allow entry by unauthorized personnel. De-energize sources of ignition within 100 feet of the spill, including vehicle engines. Should a spill be of the nature or extent that it cannot be safely contained, or poses an imminent threat to human health or the environment, an emergency cleanup contractor will be called out as soon as possible. Spill containment measures listed below are examples of responses to spills.

- Right or rotate containers to stop the flow of liquids. This step may be accomplished as soon as the spill or leak occurs, providing it is safe to do so.
- Sorbent pads, booms, or adjacent soil may be used to dike or berm materials, subject to flow, and to solidify liquids.
- Sorbent pads, soil, or booms, if used, must be placed in appropriate containers after use, pending disposal.
- Contaminated tools and equipment shall be collected for subsequent cleaning or disposal.

Section 11

Documentation

The implementation of the HASP must be documented on the appropriate forms (see appendices) to verify employee participation and protection. In addition, the regulatory requirements must be met for recordkeeping on training, medical surveillance, injuries and illnesses, exposure monitoring, health risk information, and respirator fit-tests. Documentation of each BC employee's health and safety records is maintained by the Health and Safety Data Manager in Walnut Creek, California.

Health and safety documentation and forms completed, as specified by this plan, are to be retained in the project file.

Other relevant project-specific health and safety documents, such as MSDSs or client-specified procedures, will be attached to this HASP in Appendix F.

Appendix A:

Air Monitoring Form

Brown AND Caldwell

Air Monitoring Form

Page ____ of ____

Instructions: Complete this form immediately prior to project start.
File in project folder when complete.

Name of Project/Site:	**Project No:**
Project/Site Location:	
Employee Performing Air Monitoring: (Print and Sign):	**Date:**

Instrument(s)

Manufacturer/Model:

Manufacturer/Model:

Manufacturer/Model:

Manufacturer/Model:

Does the instrument(s) have a current calibration per the manufacturer's instructions? ☐ Yes ☐ No

Was the instrument(s) field checked (i.e bump tested or field calibrated) per the manufacturer's instructions? ☐ Yes ☐ No

Remarks:

Monitoring Data

		P/FID (PPM)	**COLORIMETRIC TUBES (PPM)**	**RAM (mg/m^3)**	**MULTI-GAS DETECTION**			
TIME	**LOCATION AND ACTIVITY**				**%LEL**	**H2S**	**O2**	**OTHER**

Appendix B:

Site Safety Checklist

Brown AND Caldwell

Site Safety Checklist

Page ____ of ____

Instructions: Complete this form immediately prior to project start.
File in project folder when complete.

Name of Project/Site:

Project No:

Project/Site Location:

Employee Completing Checklist:
(Print and Sign):

Date:

Yes No N/A
☐ ☐ ☐ Written Health and Safety (H&S) Plan is on site?
☐ ☐ ☐ Addenda to the H&S Plan are documented on site?
☐ ☐ ☐ H&S Plan information matches conditions/activities at the site?
☐ ☐ ☐ H&S Plan read/signed by all site personnel, including visitors?
☐ ☐ ☐ Daily tailgate H&S meetings have been held/documented?
☐ ☐ ☐ Site personnel have required training and medical?
☐ ☐ ☐ Air monitoring is performed/documented per the H&S Plan?
☐ ☐ ☐ Air monitoring equipment has been calibrated daily?
☐ ☐ ☐ Site zones are set up and observed where appropriate?
☐ ☐ ☐ Access to the work area limited to authorized personnel?
☐ ☐ ☐ Decontamination procedures followed/match the H&S Plan?
☐ ☐ ☐ Decontamination stations (incl. hand/face wash) are set up and used?
☐ ☐ ☐ PPE used matches H&S Plan requirements?
☐ ☐ ☐ Hearing protection used where appropriate?

Yes No N/A
☐ ☐ ☐ Respirators are available, properly cleaned, and stored?
☐ ☐ ☐ Overhead utilities do not present a hazard to equipt./personnel?
☐ ☐ ☐ Traffic control measures have been implemented?
☐ ☐ ☐ Trenches and excavations are safe for entry?
☐ ☐ ☐ Soil Spoils are at least 2 feet from the edge of the excavation?
☐ ☐ ☐ Emergency/FA equipt. is on site as described in the H&S Plan?
☐ ☐ ☐ Drinking water is readily available?
☐ ☐ ☐ Phone is readily available for emergency use?
☐ ☐ ☐ Utility locator has cleared subject locations?
☐ ☐ ☐ Proper drum and material handling techniques are used?
☐ ☐ ☐ Waste containers/drums are labeled appropriately?
☐ ☐ ☐ Ext. cords are grounded/protected from water/vehicle traffic?
☐ ☐ ☐ Tools and equipment are in good working order?
☐ ☐ ☐ GFCIs used for portable electrical tools and equipment?

Notes

(All "no" answers must be addressed and corrected immediately. Note additional health and safety observations here):

Appendix C:

H&S Plan Acknowledgement Form

Brown AND Caldwell

H&S Plan Acknowledgement Form

Page ____ of ____

Instructions: Complete this form immediately prior to project start or as new personnel join the project.
File in project folder when complete.

Name of Project/Site:

Project No:

Project/Site Location:

Employee Performing Briefing:
(Print and Sign):

Date:

Employee Acknowledgement:

The following signatures indicate that these personnel have read and/or been briefed on this Health and Safety (H&S) Plan and understand the potential hazards/controls for the work to be performed.

Important Notice to Subcontractor(s):

Subcontractors are responsible for developing, maintaining, and implementing their own health and safety programs, policies, procedures and equipment as necessary to protect their workers, and others, from their activities. Subcontractors shall operate equipment in accordance with their standard operating procedures as well as manufacturer's specifications. Any project monitoring activities conducted by BC at the Site shall not in any way relieve subcontractors of their critical obligation to monitor their operations and employees for the determination of exposure to hazards that may be present at the Site and to provide required guidance and protection. If requested, subcontractors will provide BC with a copy of their own H&S Plan for this project or other health and safety program documents for review.

BC's Health and Safety Plan has been prepared specifically for this project and is intended to address health and safety issues solely with respect to the activities of BC's own employees at the site. A copy of BC's H&S Plan may be provided to subcontractors in an effort to help them identify expected conditions at the site and general site hazards. The subcontractor shall remain responsible for identifying and evaluating hazards at the site as they pertain to their activities and for taking appropriate precautions. For example, BC's H&S Plan does not address specific hazards associated with tasks and equipment that are particular to the subcontractor's scope of work and site activities. (e.g., operation of a drill rig, excavator, crane or other equipment). Subcontractors are not to rely on BC's H&S Plan to identify all hazards that may be present at the Site. Subcontractor personnel are expected to comply fully with subcontractor's Health and Safety Plan and to observe the minimum safety guidelines applicable to their activities which may be identified in the BC H&S Plan. Failure to do so may result in the removal of the subcontractor or any of the subcontractor's workers from the job site.

Print	Sign	Date	Print	Sign	Date

Appendix D:

Daily Tailgate Meeting Form

Brown AND Caldwell

DAILY TAILGATE MEETING FORM

Name of Project/Site:	**Project No:**
Project/Site Location:	
Employee Completing Form (*print and sign):*	**Date:**

Employee Acknowledgement:

The following signatures indicate that these personnel have read and/or been briefed on this Health and Safety (H&S) Plan and understand the potential hazards/controls for the work to be performed.

<u>Important Notice to Subcontractor(s):</u>

Subcontractors are responsible for developing, maintaining, and implementing their own health and safety programs, policies, procedures and equipment as necessary to protect their workers, and others, from their activities. Subcontractors shall operate equipment in accordance with their standard operating procedures as well as manufacturer's specifications. Any project monitoring activities conducted by BC at the Site shall not in any way relieve subcontractors of their critical obligation to monitor their operations and employees for the determination of exposure to hazards that may be present at the Site and to provide required guidance and protection. If requested, subcontractors will provide BC with a copy of their own H&S Plan for this project or other health and safety program documents for review.

BC's Fieldwork Safety Plan has been prepared specifically for this project and is intended to address health and safety issues solely with respect to the activities of BC's own employees at the site. A copy of BC's H&S Plan may be provided to subcontractors in an effort to help them identify expected conditions at the site and general site hazards. The subcontractor shall remain responsible for identifying and evaluating hazards at the site as they pertain to their activities and for taking appropriate precautions. For example, BC's H&S Plan does not address specific hazards associated with tasks and equipment that are particular to the subcontractor's scope of work and site activities. (e.g., operation of a drill rig, excavator, crane or other equipment). Subcontractors are not to rely on BC's H&S Plan to identify all hazards that may be present at the Site. Subcontractor personnel are expected to comply fully with subcontractor's Fieldwork Safety Plan and to observe the minimum safety guidelines applicable to their activities which may be identified in the BC H&S Plan. Failure to do so may result in the removal of the subcontractor or any of the subcontractor's workers from the job site.

Print	Sign	Date	Print	Sign	Date

Plan of the Day

(Describe the activities that are planned to be performed today)

Potential Hazards and Topics Discussed

(Describe the potential hazards and controls that may be associated with planned activities)

☐ Physical ☐ Natural Phenomena ☐ Chemical ☐ Electrical ☐ Biological ☐ Radiological

☐ Other (specify):

Place a copy in the project file.

Appendix E:

Incident Investigation Report

Brown AND Caldwell

Preliminary Incident Investigation Report Form

Privileged and Confidential
Do Not Distribute

Instructions:

If an incident occurs, complete all applicable information in this form, make a copy for your records, and immediately forward the original to the office Health and Safety Coordinator (HSC). If fields are not applicable, indicate with "N/A". Use separate sheet(s) if necessary and attach sketches, photographs, witness statements, or other information that may be helpful in understanding how the accident/incident occurred. For assistance in completing this form, contact your office H&S Coordinator/Specialist or your Regional Safety Unit Manager (RSUM).

HSC – Review and enter report into the BC Online Incident Reporting System within 3 workdays of receipt. File original in appropriate office health and safety file.

NOTE:

This report is important – please take the time necessary to properly complete it. Incomplete reports will be forwarded to appropriate management for review and action.

General Information

Date of Accident/Incident	**Time of Accident/Incident:**	**Date Accident/Incident Reported:**	**To Whom:**
Exact Location of Accident/Incident (Street, City, State)**:**			**BC Office:**
Name Project:			**Project Number:**
Employee Completing the Investigation (Print and Sign)**:**			**Date:**

Injured/Ill Employee/Property Damage Information

Employee Name:	**Employee No.**	**Department:**	**Phone Number:**
Job Title:		**Manager's Name and Phone Number:**	
Nature of Injury/Illness (laceration, contusion, strain, etc.)**:**		**Body Part Affected** (arm, leg, head, hand, etc.)**:**	
Describe Property Damage and Estimate Loss :			

Description of Accident/Incident

Describe the accident sequentially, beginning with the initiating event, and followed by secondary and tertiary events. End with the nature and extent of injury/damage. Name any object or substance and tell how they were included. Examples: 1) Employee was pulling utility cart that was loaded with wastepaper from office area to hallway. Wheel of utility cart caught against door casing. Bags of heavy wastepaper that were in cart fell to end of cart. Cart tipped over onto foot of employee. Right foot was crushed between utility cart and door casing, resulting in severe contusion to right foot of employee. 2) Employee was driving rental car from office to project site. Car struck icy section of road. Employee lost control of vehicle, which skidded across road into concrete abutment on side of road. Accident resulted in damage to right fender, tire, headlight, and grill.

Preliminary Incident Investigation Report Form

Privileged and Confidential
Do Not Distribute

Analysis of Accident Causes

Immediate Causes - Substandard Actions

What substandard actions caused or could have caused the accident/incident? State the actions on the part of the employee or others that contributed to the occurrence of the accident/incident. Examples: 1) Employee overloaded the utility cart with wastepaper. 2) Employee exceeded safe speed on icy road, and was inattentive to hazard.

Codes **(check all that apply)**

☐ Failure to recognize hazard(s)
☐ Failure to use equipment or use it properly
☐ Failure to use PPE or use it properly
☐ Failure to warn, secure, or barricade
☐ Horseplay
☐ Improper lifting
☐ Improper loading, placement, or position for task
☐ Performing excessive repetitive activities
☐ Operating equipment without authority
☐ Removing or making safety devices inoperable
☐ Servicing equipment in operation
☐ Using defective equipment
☐ Unclassified (not determined)
☐ Other (specify):

____

Immediate Causes - Substandard Conditions

What substandard conditions caused or could have caused the accident/incident? State the conditions that existed at the time of the accident (the specific control factors that were or may have been the direct or immediate cause or causes of the accident). Examples: 1) Wheel of utility cart was worn and would not roll properly; utility cart was overloaded with wastepaper. 2) Road was covered with icy spots; weather was foggy.

Codes **(check all that apply)**

☐ Congested or restricted area
☐ Defective tools, equipment, or materials
☐ Fire or explosion hazards
☐ Hazardous environmental conditions (vapors, dusts, etc.)
☐ High or low temperature exposures
☐ Inadequate guards or barriers
☐ Inadequate or excessive illumination
☐ Inadequate ventilation
☐ Inadequate walking/working surfaces
☐ Noise Exposures
☐ Poor housekeeping
☐ Radiation exposures
☐ Unclassified (not determined)
☐ Other (specify):

____

Basic Causes - Personal and Job Factors

What personal and/or job factors caused or could have caused the accident/incident? State the influencing factors or underlying causes, either conditions or actions or both, that contributed to the accident/incident. Examples: 1) Employee had not been instructed in overloading hazards. 2) Employee had not been trained in driving under winter conditions; company has no driver training program.

Codes **(check all that apply)**

Personal Factor Codes

☐ Alcohol or drug influence (possible)
☐ Fatigue
☐ Inadequate skill, capability, knowledge, or training
☐ Inattention
☐ Rushing to complete work
☐ Unclassified (not determined)
☐ Other (specify):

____

Job Factor Codes

☐ Inadequate engineering
☐ Inadequate leadership/supervision
☐ Inadequate maintenance, wear, abuse, or misuse
☐ Inadequate planning or accelerated schedule
☐ Inadequate tools/equipment
☐ Inadequate work standards/procedures
☐ Unclassified (not determined)
☐ Other (specify):

____

Remedial Actions

Describe the actions taken or planned to prevent recurrence of accident/incident - provide the implementation date and person responsible for any planned corrective action.. Examples: 1) Wheels of utility cart were replaced with larger size wheels; all carts were inspected for safe operation; employees were instructed in overloading hazards. 2) All project personnel were instructed at the safety training meeting on driving under hazardous conditions; driver training program will be implemented.

Codes (check all that apply)

☐ Equipment repair or replacement
☐ Improve design or construction
☐ Improve housekeeping
☐ Improve PPE
☐ Install safety guard or device
☐ Reinstruction or reprimand of personnel involved
☐ Temporary/permanent reassignment of personnel
☐ Work method change
☐ Use safer materials or equipment
☐ Develop and publish lessons learned
☐ Unclassified (not determined)
☐ Other (specify):

____

Distribution. Original – Office Health and Safety Coordinator; Copy #1 – Originator

Appendix F:

Miscellaneous Health and Safety Information

Appendix B: SOPs

B-1

Investigation-Derived Waste Handling

Brown AND Caldwell
2 Park Way, Suite 2A
Upper Saddle River, New Jersey 07458
Tel: 201-574-4700
Fax: 201-236-1607

Technical Memorandum

Prepared by: Brown and Caldwell

Project Title: Standard Operating Procedures (BCNNJ-SOP-IDW1-0812)

Project No: 141321.600.004

SOP Version 1.0

Subject: Investigation-Derived Waste Handling

Date: October 11, 2012

Prepared by:

Charles Meyn, P.G.
Hydrogeologist III

Reviewed by:

Scott MacMillin, P.G.
Managing Hydrogeologist

Table of Contents

1. Scope and Objectives

The objective of this standard operating procedure (SOP) is to establish consistent methods to handle and manage all Investigation-Derived Waste (IDW), including:

- **Non-Aqueous Waste** - Both hazardous and non-hazardous, e.g., soil cuttings, contaminated debris or equipment.
- **Water** - Water containing both hazardous and non-hazardous contaminant concentrations , e.g., well development water, purge water, rinse water from decontamination, product removal.
- **Liquid Waste** - Both hazardous and non-hazardous non-aqueous liquids, e.g., product removal from wells.
- **Personal Protective Equipment (PPE)** - e.g., gloves, spent respirator cartridges, chemical-resistant coveralls.

This procedure has been developed in conformance with the “Field Sampling Procedures Manual”, (NJDEP, 2005) and applicable ASTM standards:

2. Applicability

Investigation sampling activities may generate solid, liquid, and Personal Protective Equipment (PPE) waste. The IDW Handling Procedures SOP will be implemented primarily on-site.

This SOP does not describe the Brown and Caldwell legal requirements related to waste handling subcontracting and the signing of manifests. Under no circumstances will a Brown and Caldwell employee acts as an agent and/or sign manifests without express contractual authority that has been reviewed and approved by Brown and Caldwell corporate Legal Department. For addition information, The Brown and Caldwell Project Manager must contact the Legal Department for additional information.

3. Responsibilities

Project Manager, or designee, will have the responsibility to oversee and ensure that the IDWs are properly handled and managed in accordance with this SOP and any site-specific or project-specific planning documents. Field personnel will be accountable for the comprehension and implementation of this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, labels, records and equipment needed to complete the field activities. All BC personal who may act as an agent and/or sign manifests for a client must receive training in required hazardous materials shipping paperwork, labeling and placarding in accordance with 49 CFR parts 171-180.

4. Definitions

Designated Waste: A solid or liquid waste which is not defined as hazardous, but which still may present a threat to groundwater, and which requires handling differently than a non-hazardous inert waste.

D.O.T (U.S. Department of Transportation): Typically referred to when specifying a type of container that is approved for transporting hazardous substances, either materials or waste, on public roads.

Hazardous Waste: Hazardous Waste: Soil, liquid, or other wastes generated from site investigations that exhibit toxic (human or ecological effects), ignitable, corrosive, or reactive characteristics as defined by applicable state or federal regulation or which is otherwise classified as hazardous. Such waste requires special handling and documentation of disposal.

IDW (Investigation-Derived Waste): Typically solid (e.g., soil) or liquid (e.g., groundwater, decontamination fluids) wastes resulting from field activities.

Non-Hazardous Waste: A waste that does not exhibit characteristics of a hazardous waste and which is not otherwise classified as hazardous. Non-hazardous waste can also be designated or inert waste.

PPE (Personal Protective Equipment): Worn by workers when potential for exposure to hazardous materials exists.

HASP (Health and Safety Plan): Plan written to coordinate and outline precautions that will be taken to initiate and monitor worker safety.

5. Required Materials

The equipment and supplies required for implementation of this SOP include the following:

- **Containers for Waste** - e.g., 55-gallon open and closed top drums and material to cover waste to protect from weather (e.g., plastic covering). Alternatively, large volumes of waste may be contained roll-off containers, as appropriate.
- **Equipment** - i.e., pumps, generators, water/interface level indicators, safety monitoring equipment
- **Hazardous/Non-Hazardous Drum Labels** - Waterproof
- **Permanent Marking Pens**
- **Inventory Forms for Project File**
- **Miscellaneous Materials** - Plastic garbage bags, zip lock storage bags, roll of plastic sheeting
- **PPE** - Steel-toed boots, chemical resistant gloves, coveralls, safety glasses, and any other PPE required in the site-specific HASP.

6. Methods

The following methods are used to handle the IDW.

6.1 Labeling

Containers used to store IDW must be properly labeled. Two general conditions exist: 1) from previous studies or on-site data, waste characteristics are known to be either hazardous or non-hazardous; or 2) waste characteristics are unknown until additional data are obtained.

For situations where the waste characteristics are known, the waste containers should be packaged and labeled in accordance with state regulations and any federal regulations that may govern the labeling of waste (e.g., CFR, Title 40, Part 261).

The following information shall be placed on all non-hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings, floating product);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

The following information shall be placed on all hazardous waste labels:

- Description of waste (i.e., purge water, soil cuttings);
- Generator information (i.e., name, address, contact telephone number);

- EPA identification number (supplied by on-site client representative);
- Date when the waste was first accumulated.

When the final characterization of a waste is unknown, a notification label should be placed on the drum with the terms "waste characterization pending analysis" and the following information included on the label:

- Description of waste (i.e., purge water, soil cuttings);
- Contact information (i.e., contact name and telephone number);
- Date when the waste was first accumulated.

Once the waste has been characterized, the label should be changed as appropriate for a non-hazardous or hazardous waste. Waste labels should be constructed of a weatherproof material and filled out with a permanent marker to prevent being washed off or becoming faded by sunlight. In addition when waste may be staged onsite for a significant period of time the label information should be duplicated on the side of the drum with a paint pen. It is recommended that waste labels be placed on the side of the container, since the top is more subject to weathering. However, when multiple containers are accumulated together, it also may be helpful to include labels on the top of the containers to facilitate organization and disposal.

Each container of waste generated shall be recorded in the field notebook used by the person responsible for labeling the waste. After the waste is transported off-site (see sections 6.4 – 6.5 below), an appropriate record shall be made in the same field notebook to document proper disposition of IDW.

6.2 Types of Site Investigation Waste

Several types of waste are generated during site investigations that may require special handling. These include solid, liquid, and used PPE, as discussed further below.

6.2.1 Non-Aqueous Waste

Soil cuttings and drilling mud generated during investigation activities shall be kept on-site in containers. Covers should be included on the containers and must be secured at all times and only open during filling activities. The containers shall be labeled in accordance with this SOP. An inventory containing the source, volume, and description of material put in the containers shall be logged on prescribed forms and kept in the project file.

6.2.2 Water

Groundwater generated during monitoring well development, purging, and sampling can be collected in truck-mounted containers and/or other transportable containers (i.e., 55-gallon drums). Lids or bungs on drums must be secured at all times and only open during filling or pumping activities. The containers shall be labeled in accordance with this SOP. Waste that is generated during equipment decontamination shall be collected in a separate container. All waste containers shall be properly accounted for through an inventory process.

6.2.3 Personal Protective Equipment (PPE)

PPE that is generated throughout investigation activities shall be placed in plastic garbage bags and stored in secure containers. The containers shall be properly sealed and labeled according to this SOP. If the solid or liquid waste is characterized as hazardous waste, then the corresponding PPE should also be disposed as hazardous waste. If not, all PPE should be disposed as non-hazardous waste at an appropriate facility. Trash that is generated as part of field activities may be disposed of in regular collection facilities as long as the trash was not exposed to hazardous media.

6.3 Waste Characterization

Prior to transport of waste offsite by a certified hazardous waste hauler the hazardous nature of the material will be properly characterized. Brown and Caldwell employees must coordinate with the waste disposal contractor to develop a characterization plan that fulfills the requirements of the waste hauler and final disposal facility. In some cases previous waste characterization or other sampling data may be used to develop the characterization but often the waste must be sampled to establish the characterization. Waste characterization sampling should be conducted in accordance with the regulations of any involved state and federal agencies.

6.4 Waste Accumulation on Site

Solid, liquid, or PPE waste generated during investigation activities that are classified as non-hazardous or “characterization pending analysis” should be disposed of as soon as possible. Until disposal, such containers should be inventoried, stored as securely as possible, and inspected regularly, as a general good practice.

Solid, liquid, or PPE waste generated during investigation activities that are classified as hazardous shall not be accumulated on-site longer than 90 days. All hazardous waste containers shall be stored in a secured storage area. The following requirements for longer term hazardous waste storage areas must be implemented:

- Proper hazardous waste signs shall be posted as required by state regulations
- Secondary containment to contain spills;
- Spill containment equipment must be available;
- Fire extinguisher;
- Adequate aisle space for unobstructed movement of personnel.

Throughout the project, an inventory shall be maintained to itemize the type and quantity of the waste generated.

6.5 Waste Disposal

Solid, liquid, and PPE waste will be characterized for disposal through the use of client knowledge, laboratory analytical data created from soil or groundwater samples gathered during the field activities, and/or composite samples from individual containers.

All waste generated during field activities will be stored, transported, and disposed of according to applicable state, federal, and local regulations. All wastes classified as hazardous will be disposed of at a licensed treatment storage and disposal facility or managed in other approved manners.

In general, waste disposal should be carefully coordinated with the facility receiving the waste. Facilities receiving waste have specific requirements that vary even for non-hazardous waste, so characterization should be conducted to support both applicable regulations and facility requirements.

6.6 Waste Transport

A state certified hazardous waste hauler shall transport all wastes classified as hazardous. Typically, the facility receiving any waste can coordinate a hauler to transport the waste. Shipped hazardous waste shall be disposed of in accordance with all RCRA/USEPA requirements. All waste manifests or bills of lading will be signed either by the client or the client’s designee, which can in special circumstances be the project manager if acting as an authorized agent for the client. Under no circumstances will a Brown and Caldwell employee acts as an agent and/or sign manifests without express contractual authority that has been reviewed and approved by Brown and Caldwell corporate Legal Department.

References

U.S. EPA Guide to Management of Investigative-Derived Waste, Publication: 9345.3-03FS, April 1992.

Code of Federal Regulations, Title 40, Section 262.32, Standards Applicable to Generators of Hazardous Wastes, Subpart C – Pre-transport Requirements, Marking, periodically updated – use most current version.

B-2

Soil Sampling

Brown AND Caldwell

2 Park Way, Suite 2A
Upper Saddle River, New Jersey 07458
Tel: 201-574-4700
Fax: 201-236-1607

Technical Memorandum

Prepared by: Brown and Caldwell

Project Title: Standard Operating Procedures (BCNNJ-SOP-SS2-0913)

Project No: 141321.600.004

SOP Version 2.0

Subject: Soil Sampling

Date: August 21, 2012

Prepared by:

Charles Meyn, P.G.
Hydrogeologist III

Reviewed by:

Scott MacMillin, P.G.
Managing Hydrogeologist

Table of Contents

1. Objectives

The objective of this standard operating procedure (SOP) is to provide the methods to be used for the proper sampling of soils for environmental investigations and to provide standardized reporting formats for documentation of data. A further objective is to provide a detailed technical resource that can be used both for preparing detailed field sampling plans and for training. These methods are intended to be both technically and legally defensible while embracing a common sense approach. Furthermore, these methods attempt to address groundwater sample collection under a wide variety of physical and regulatory conditions.

2. Applicability

This procedure is intended for use by Brown and Caldwell for the sampling of surficial and subsurface soils and associated documentation as part of an environmental investigation. This procedure is also intended for obtaining representative samples of stockpiled materials intended for off-site disposal or importation as backfill or cover material. Specific sampling methods and procedures depend on project specific objectives and subsurface conditions and should be discussed in project specific planning documents.

2.1 Health and Safety

Potential physical and chemical hazards will need to be addressed when planning soil sampling activities. A health and safety plan that addresses known and anticipated field conditions must be prepared prior to field work and be followed during soil sampling.

3. Responsibilities

The project manager is responsible for ensuring that the project involving soil sampling is properly planned and executed and that the safety of personnel from chemical and physical hazards associated with the sampling is provided for. The field staff is responsible for conducting the sampling and to ensure that the project specifications defined in the project-specific planning documents are followed and that pertinent data are recorded on appropriate forms and in the field notebook. The site safety officer, typically the field geologist or engineer, is responsible for overseeing the health and safety of Brown and Caldwell employees and for stopping work if necessary to fix unsafe conditions observed in the field.

4. Required Materials

Many materials are required for successfully completing a soil sampling event. The field personnel should be aware of what is required to conduct the work in accordance with the project specific sampling plan and have all required materials available and in working order prior to the beginning of the sampling. The following is a general list of materials that are needed for performing the tasks outlined in this SOP.

- Health and Safety supplies (e.g., steel toed boots, gloves, hard hat, hearing protection, etc.)
- Soil sampling equipment such as scoops, hand augers, trowels, rulers, plastic bags, driller jars, aluminum foil, etc., in accordance with the project specific goals and procedures
- Soil screening equipment such as a Photo-ionization detector (PID) in accordance with the project specific goals and procedures
- Analytical sample containers

- Decontamination Supplies
- Logbook
- Site Map
- General tools

5. Procedure

5.1 Introduction

5.1.1 Preparatory Office Activities

Physical aspects of the sampling program will be organized in the office prior to embarking on a field sampling project. The time spent in the field is very valuable and should be spent on sample collection, making field measurements and recording data and not on the organization of equipment and containers.

- **Sampling Sequence** - The sequence of sampling will be pre determined on the basis of existing soil quality data if available. Generally, the least sample locations will be sampled first, proceeding to the progressively more contaminated sample locations.

5.1.2 Preparatory Field Activities

The following procedures will be conducted in the field prior to soil sampling.

- **Tailgate Meeting and Rig Maintenance Check** – The field team, including the drilling subcontractor if applicable, will go over the work plan and potential hazards that may be encountered to ensure that all work is performed to project specifications and in a safe manner. In addition, if drilling equipment is being used the drilling subcontractor will inspect it and make sure it is in safe working order prior to the beginning of sampling activities.
- **Preparation of Work Area** - A suitable work area will be established around the perimeter of the sample locations. This will provide a clean surface on which sampling equipment can be placed such that it will not become inadvertently contaminated. This work area may be prepared by placing new polyethylene (PE) sheeting on the ground around the well, taking care not to step on it. Alternatives can include the placement of a clean PE lined trash can or a clean PE covered table adjacent to the sampling location.

5.2 Soil Sampling

5.2.1 Collection of Sub-Surface Soil Samples from Soil Borings

Soil borings may be advanced using a variety of techniques such as direct-push techniques, hollow-stem auger drilling methods, and/or fluid-rotary methods, depending on the site logistics and the sampling objectives at a given area of concern. The final decision to change drilling methods will be based on the drilling contractor's and environmental consultant's experience with concurrence with the governing agency. Soil samples will be collected from the borings using split- barrel samplers (auger or wet-/mud-rotary methods) or macro-core samplers with dedicated acetate liners (direct-push rig). Samples from each barrel/sampler will be screened in the field using a PID and readings for each sample interval will be recorded on a field log book. Soil samples will be observed for physical properties such as color, sorting, etc. The grain size of the sampled soils will be visually characterized in the field by an experienced hydrogeologist and logged in accordance with a system after Burmister (1959). In addition, the Burmister classification will be converted to the Unified Soil Classification System (USCS) on the final boring log. Upon completion of drilling, a boring log will be prepared by the hydrogeologist that contains specific details regarding the drilling or monitoring well procedure, a description of the encountered subsurface materials, any information obtained from field readings (PID, etc.) and observations regarding evidence of contamination (i.e., discoloration, odor, etc.), and a drawing of record of the completed monitoring well. Analytical samples will be removed from the split spoon or acetate liner and placed in a clean, decontaminated stainless steel mixing bowl to be homogenized. Homogenization of the soil ensures are all completed sample containers will have an equally representative sample of the targeted soil interval. Following homogenization of the soil the samples will be placed in the laboratory prepared sample containers using only clean decontaminated tools, for example an unused plastic spoon. VOC sample containers will be collected first to ensure that volatilization of the targeted analytes does not occur. Once collected the samples will be stored and shipped in a manner consistent with the presiding regulatory authorities' guidance and regulations. All sample material not used for analytical samples or reserved for later lithologic analysis will be combined with the other investigation derived soil wastes.

5.2.2 Collection of Surficial Soil Samples

Before collecting a surficial soil sample (0-6 inches below the ground surface or 0-12 inches below the ground surface) the sample location will be carefully cleared by removing any vegetation layers, surface debris, or upper one centimeter of soil surface, as applicable. The soil samples will be collected using decontaminated stainless-steel scoops, hand augers, trowels, or equivalent tools. The collection of surface samples for VOCs will be conducted using an Encore™ Sampler in accordance with agency requirements. The sampling device is inserted into a freshly exposed soil surface (ground surface or soil core sampler). The 5-gram plug of soil is then capped and sent to the laboratory where it will be preserved, extracted and analyzed. To satisfy the volume requirements of multiple bottle sets, surface soil samples (other than those collected for VOCs using the Encore™ sampler) will be homogenized either in situ or in a decontaminated stainless steel mixing bowl or tray before being transferred to bottles. A description of the soil data (e.g., soil description, location, time, etc.) will be recorded in the project field book as described in Section 5.2.1.

5.2.3 Collection of Stockpile Samples

An important objective of any stockpile sampling is to obtain samples that are representative of the entire stockpile. Thus, in addition to observing sampling frequencies required by the work plan or other document, it is important to locate samples at various points on and around the stockpile, and to obtain the samples from below the surface of the stockpile (e.g., by spade or similar device). The locations and depths of the samples, whether they will be analyzed individually or composited, should be recorded by in the field log.

Stockpile samples will be collected using decontaminated stainless-steel scoops, hand augers, trowels, or equivalent tools. The collection of surface samples for VOCs will be conducted using an Encore™ Sampler in accordance with agency requirements. The sampling device is inserted into a freshly exposed soil surface of the stockpile. The 5-gram plug of soil is then capped and sent to the laboratory where it will be preserved, extracted and analyzed. To satisfy the volume requirements of multiple bottle sets, stockpile samples (other than those collected for VOCs using the Encore™ sampler) will be homogenized in a decontaminated stainless steel mixing bowl or tray before being transferred to bottles. A description of the soil data (e.g., soil description, location, time, etc.) will be recorded in the project field book as described in Section 5.2.1.

6. Quality Assurance/Quality Control

Soil sampling details will be documented in detail in the field. Field documentation will consist of a sampling chronology and notes in the site field book, including the field descriptions of each sample interval and laboratory chains of custody. The field sample descriptions should include, at a minimum, the following:

- Location/boring identification

- Depth interval
- Sample Recovery
- PID, OVA or other relevant screening results
- Blow counts of Standard Penetration Test (SPT) if applicable
- Physical description of the sample including Burmister soil description, moisture, observations of impacts and anything else of note

Deviations from project-specific planning documents will be documented and explained in daily field notes. The program manager will be contacted to discuss project deviations. Field quality control can be maintained through 1) making sure employees are properly trained to conduct the work being implemented, and 2) performing routine field audits to evaluate how well employees are following procedures.

7. Documentation and Recordkeeping

Field notes, Chains-of-Custody, and Health and Safety forms will be submitted to the Project Manager or designate immediately following the field event for checking and revision purposes. The Project Manager or designate shall review and transmit the completed forms for incorporation into the project file.

B-3

Field Equipment Decontamination

Brown AND Caldwell

2 Park Way, Suite 2A
Upper Saddle River, New Jersey 07458
Tel: 201-574-4700
Fax: 201-236-1607

Technical Memorandum

Prepared by: Brown and Caldwell

Project Title: Standard Operating Procedures (BCNNJ-SOP-FEQ1-0812)

Project No: 141321.600.004

SOP Version 1.0

Subject: Field Equipment Decontamination

Date: August 21, 2012

Prepared by:

Charles Meyn, P.G.
Hydrogeologist III

Reviewed by:

Scott MacMillin, P.G.
Managing Hydrogeologist

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1. Scope and Objectives

Small, non-dedicated sampling equipment used to handle and collect a sample medium must be decontaminated prior to each use. This equipment would include water sample pumps, tube soil samplers, sediment dredge samplers, scoops, etc. This would not include larger equipment such as other drilling tools (e.g., bits and rods), excavation equipment, etc.

This procedure has been developed in accordance with ASTM D-5088(current version) “Standard Practice for Decontamination of Field Equipment Used at Non-radioactive Waste Sites” and the Field Sampling Procedures Manual, (NJDEP, 2005).

2. Responsibilities

Project Manager, or designee, will be responsible for maintaining compliance with the requirements of the SOP.

The field sampling personnel are responsible for implementation of the requirements of this SOP, including record keeping.

3. Required Materials

The equipment and supplies required for implementation of this SOP include the following:

- **Laboratory Detergent** - Alconox®, Liquinox®, or equivalent
- **Potable Water**
- **Acid Solution** - Made from 10% reagent grade nitric or hydrochloric acid and deionized water (1% acid solution to be used on equipment constructed of low carbon steel).
- **Organic Solvent** - Various organic solvents of very high purity will be used as a rinse of materials contaminated with organic compounds. Selection of the particular solvent will depend on the relative solubility of the contaminants of concern, usually based on polarity. For example, relatively polar solvents such as methanol or acetone are good solvents for other polar contaminants. Hexane, a relatively non-polar solvent, provides a good rinse agent for relatively non-polar contaminants such as PCBs and pesticides.
- **Reagent Water** – Type II prepared by distillation, as per ASTM D-1193(current version) contained in polyethylene or PTFE (e.g., Teflon®) wash bottle.
- **Assorted Brushes and Buckets**
- **Site Field Book**

4. Procedure

This procedure is intended as a general framework for properly decontaminating small sampling equipment before it is used for the collection of each sample. More specialized procedures may need to be instituted depending on the nature of contamination, site conditions and the nature of the equipment being cleaned. All procedures should be outlined in the site Work Plan prior to the onset of field activities.

Contaminated equipment will be cleaned by following the steps listed below:

- Wash in potable water and laboratory detergent with a brush to remove particles of soil or sediment.
- Equipment with internal mechanisms that cannot be contacted with a brush (e.g., submersible pumps) will be washed by circulating the detergent solution through the equipment. (Note: some jurisdictions may require equipment disassembly rather than recirculation of solutions).Rinse with potable water.
- Rinse with organic solvent specific to the contaminant, only if the samples will undergo analyses for organic parameters.
- Rinse in acid solution, only if the samples will undergo analyses for inorganic parameters.
- Rinse with deionized water from wash bottle.
- Investigation-derived waste (IDW) including wash and rinse water and solvents will be contained pending appropriate disposal.
- Store decontaminated equipment such that it does not come in contact with potentially contaminated equipment or surfaces, e.g., wrapped in foil.
- Note decontamination in the site field book

B-4

Field Instrument Calibration

Brown AND Caldwell

2 Park Way, Suite 2A
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Tel: 201-574-4700
Fax: 201-236-1607

Technical Memorandum

Prepared by: Brown and Caldwell

Project Title: Standard Operating Procedures (BCNNJ-SOP-FIC1-0812)

Project No: 141321.600.004

SOP Version 1.0

Subject: Field Instrument Calibration

Date: August 21, 2012

Prepared by:

Charles Meyn, P.G.
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Reviewed by:

Scott MacMillin, P.G.
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Attachments

Attachment A	Example Field Calibration Form

1. Objectives

The objective of this Standard Operating Procedure (SOP) is to provide general procedures for the calibration of field instruments used during field investigations. These instruments are used for field sample characterization and heath and safety monitoring.

2. Applicability

This general procedure will be used during field activities when field instruments are used for the collection of field data. The general use and calibration of these instruments are discussed in this SOP and should be supplemented (or superseded, if necessary) with the manufacturer's calibration and maintenance instructions.

3. Responsibilities

The Project Manager, or designee, is responsible for maintaining compliance with the requirements of the SOP.

The field sampling personnel are responsible for implementation of the requirements of this SOP, including record keeping.

4. Definitions

Calibration – Procedure used to check, adjust, and/or demonstrate by comparison to a standard that an instrument is reading correctly.

CGI – Combustible Gas Indicator

DNAPL – Dense Non-aqueous Phase Liquid

LNAPL – Light Non-aqueous Phase Liquid

OVA – Organic Vapor Analyzer

OVM – Organic Vapor Meter

PID – Photo Ionization Detector

FID – Flame Ionization Detector

5. Required Materials

The materials required for this SOP include the following:

- Bound field logbooks,
- Black or blue water proof and/or indelible ink pens,
- Instrument Calibration Form(s) – specific to each instrument,
- Calibration gases and standard solutions, and materials and secondary collection containers (Tedlar bags, tubing, etc.) – specific to each instrument,
- Replacement batteries and parts (if applicable) – specific to each instrument.

Instruments used during field activities may include, but are not limited to, the following:

- Water Quality Instruments (e.g., pH, temperature, conductivity, dissolved oxygen, turbidity, oxidation reduction potential),
- Water level indicators,
- Product Interface probes (LNAPL and DNAPL),
- Organic vapor meters (OVMs),
- Organic vapor analyzers (OVAs),
- Photo Ionization Detectors (PIDs),
- Flame Ionization Detectors (FIDs),
- Combustible gas indicators (CGI), and
- Oxygen (O2) Monitors.

6. Procedure

This SOP includes the methods for field instrument calibration, calibration documentation and corrective action procedures that will be implemented during field activities. Prior to field activities, a determination will be made as to which instruments will be needed for the field activities. Some instruments may be available from an office equipment pool or from an equipment rental/supply company. Field personnel should procure the necessary instruments, calibration gases and/or standard solutions, and other necessary equipment and materials sufficiently in advance of the beginning of the field activities. Consideration should be made for specialty instruments and materials that may take longer to obtain.

Prior to field mobilization, instruments that will be used during the field activities will be checked for proper operation, cleanliness, and calibration. Ideally, rented field equipment will be supplied with pre-calibrated equipment with appropriate calibration records.

The calibration activities will be conducted in accordance with manufacturer's procedures, where applicable. In the event that manufacturer procedures are not available, standard, generally-accepted calibration procedures will be used. Calibration verification will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of instrument malfunction or questions in readings are observed. Some instruments, such as field water quality meters, or field gas chromatographs, may require more frequent calibration verification depending upon project quality objectives.

In general, instrument identification and calibration will include the following steps:

- Determine which instruments are needed for the specific field tasks;
- Obtain the necessary instruments and associated calibration gases and/or standard solutions for calibration;
- Check expiration dates on calibration gases and/or standard solutions. Replace, if out of date;
- Obtain other equipment and materials that are needed for calibration and use;
- Assemble the instrument and turn it on, allowing the instrument to stabilize;
- Check battery charge and recharge or replace (if necessary);
- Check carrier gas volumes, and recharge if necessary [e.g. hydrogen carrier gas used for in a flame ionization detector (FID)];
- Clean the instrument (if necessary);
- Calibrate the instrument prior to field use in accordance with manufacturer's procedures, and if necessary adjust the instrument to meet calibration specifications (this step is sometimes referred to as the initial calibration);

- If instrument malfunctions and can not be corrected, obtain another instrument and have the other repaired (see Section 6 for Corrective Action Procedures);
- Clean and decontaminate the instrument after use, and before storage;
- Conduct calibration verifications at least once per day, or as needed;
- Conduct final calibration verification at the end of each day, or at completion of field measurement collection for the day;
- Document calibration activities and results, and
- Recharge batteries, add carrier gases (if applicable), and regenerate the instrument (if applicable) at the end of each day or as needed. This should be carried out in a non-hazardous area.

Some manufacturers recommend field calibration procedures that are inadequate for verifying instrument linearity and calibration range. For example, some commercially available water quality meters may have a stock calibration mixture that is used during an “easy to conduct” calibration which consists of pressing a “calibrate” button on the instrument while the probes are in stock solution. The problem with this calibration method is that it only provides a single point calibration. This is inadequate for the field measurements collected during water quality monitoring because of the wide range of conditions that may be encountered. Typically, more involved calibration of these instruments requires disassembling the instrument probe assembly, which is not recommended. Instrument calibration and accuracy should be checked by using at least two different commercially-available standard solutions over a range of values (e.g., pH buffers at 4 and 10) to check that the meter is providing accurate readings over a range of conditions. These solutions should be separate from the solution provided by the manufacturer. These additional calibration steps are useful for applications requiring a high degree of accuracy but are not necessary for applications such as initial screening or evaluating relative change.

Important Note: Equipment rental suppliers may supply applicable calibration standards. However, calibration gasses are frequently not provided and may need to be procured separately. It should be noted that shipping restrictions may require calibration gases to be shipped by ground transport.

A record will be maintained of the calibrations and calibration verification. The records will include the following information, where applicable:

- Date and time of activities,
- Project name and number,
- Personnel conducting the calibration,
- Serial and/or meter numbers,
- Instrument name and model number,
- Calibration gases or standard solutions used, concentration of the gases and solutions used, and the associated units (if applicable), and lot numbers of calibration intervals;
- Instrument readings before and after calibration, and
- Instrument readings of calibration verification data.

Personnel responsible for the use of these instruments will read the manufacturer’s instruction manual and will be adequately familiar with the use, calibration, and maintenance of the instrument prior to instrument use. The calibration, maintenance and use of these instruments will be conducted in accordance with the manufacturer’s specifications and procedures. If instrument calibration cannot be met or if the instrument is malfunctioning, obtain another instrument and repair the malfunctioning instrument immediately (see Section 6 Corrective Action).

Calibration activities will be recorded in the field logbooks and/or on pre-printed calibration logs. Calibration data may be recorded in the Instrument Calibration Record or within the field logbook. An example of this calibration record is included as an attachment. This record can be modified as necessary to accommodate specific instruments.

7. Corrective Action Procedures

If an instrument can not be successfully calibrated or if it is malfunctioning, the instrument will be immediately placed out of service. In the event that this occurs during the course of the field activities, it will be necessary to procure a replacement instrument and/or repair the instrument before continuation of field activities. Under no circumstances should field personnel continue with activities until a replacement is obtained or approval from the PM or their designee is obtained. Instances of instrument failure and corrective actions taken will be documented in the field logbook.

Field instruments can be affected by rainfall, changes in temperature, humidity, and barometric pressure and/or use in other aggressive environments. Instrument calibration should be checked when significant changes in ambient conditions occur. In addition, instrument calibration should be checked if maintenance activities (e.g., battery replacement, lamp replacement, or refueling) are required, if instrument malfunctions occur, or when questionable readings are observed. Calibration verification and recalibration activities shall be conducted and documented as outlined in Section 5.0.

8. Corrections and Reviews

Corrections and reviews of calibration records will be completed in accordance with the SOP for Field Notes and Documentation.

9. Document Archive

At the completion of the project, the calibration records will be stored in the project files in accordance with Brown and Caldwell procedures. This will generally include scanning to PDF and saving in the project folder.

Attachment A: Example Field Calibration Form

B-5

Direct Push Drilling

Designation: D6282 – 98 (Reapproved 2005)

Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations[1]

This standard is issued under the fixed designation D6282; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide addresses direct push soil samplers, which also may be driven into the ground from the surface or through prebored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by a combination of static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or side wall samplers. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment with incremental drill hole excavation. Other sampling standards, such as Test Methods D1586 and D1587 and Practice D3550 apply to rotary drilling activities. This guide does not address advancement of sampler barrel systems with methods that employ cuttings removal as the sampler is advanced. Other drilling and sampling methods may apply for samples needed for engineering and construction applications.

1.2 Guidance on preservation and transport of samples, as given in Guide D4220, may or may not apply. Samples for chemical analysis often must be subsampled and preserved for chemical analysis using special techniques. Practice D3694 provides information on some of the special techniques required. Additional information on environmental sample preservation and transportation is available in other references (**1, 2**).[2] Samples for classification may be preserved using procedures similar to Class A. In most cases, a direct push sample is considered as Class B in Practice D4220 but is protected, representative, and suitable for chemical analysis. The samples taken with this practice do not usually produce Class C and D (with exception of thin wall samples of standard size) samples for testing for engineering properties, such as shear strength and compressibility. Guide D4700 has some information on mechanical soil sampling devices similar to direct push techniques, however, it does not address most direct push sampling methods. If sampling is for chemical evaluation in the Vadose Zone, consult Guide D4700 for any special considerations.

1.3 Field methods described in this guide, include the use of discreet and continuous sampling tools, split and solid barrel samplers and thin walled tubes with or without fixed piston style apparatus.

1.4 Insertion methods described include static push, impact, percussion, other vibratory/sonic driving, and combinations of these methods using direct push equipment adapted to drilling rigs, cone penetrometer units, and specially designed percussion/direct push combination machines. Hammers providing the force for insertion include drop style, hydraulically activated, air activated and mechanical lift devices.

1.5 Direct push soil sampling is limited to soils and unconsolidated materials that can be penetrated with the available equipment. The ability to penetrate strata is based on hammer energy, carrying vehicle weight, compactness of soil, and consistency of soil. Penetration may be limited or damage to samplers and conveying devices can occur in certain subsurface conditions, some of which are discussed in 5.5. Successful sample recovery also may be limited by the ability to retrieve tools from the borehole. Sufficient retract force must be available when attempting difficult or deep investigations.

1.6 This guide does not address the installation of any temporary or permanent soil, groundwater, vapor monitoring, or remediation devices.

1.7 The practicing of direct push techniques may be controlled by local regulations governing subsurface penetration. Certification, or licensing requirements, or both, may need to be considered in establishing criteria for field activities.

1.8 The values stated in SI units are to be regarded as standard: however, dimensions used in the drilling industry are given in inch-pound units by convention. Inch-pound units are used where necessary in this guide.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

Current edition approved Jan. 1, 2005. Published February 2005. Originally approved in 1998. Last previous edition approved in 1998 as D6282–98. DOI: 10.1520/D6282-98R05.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

1.10 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a projects's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents

D4220 Practices for Preserving and Transporting Soil Samples

D4700 Guide for Soil Sampling from the Vadose Zone

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5092 Practice for Design and Installation of Ground Water Monitoring Wells

D5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D6001 Guide for Direct-Push Ground Water Sampling for Environmental Site Characterization

3. Terminology

3.1 *Definitions*—General definitions for terminology used in this guide are in accordance with Terminology D653. Definitions for terms related to direct push water sampling for geoenvironmental investigations are in accordance with Guide D6001.

3.1.1 *assembly length, n*—length of sampler body and riser pipes.

3.1.2 *borehole, n*—a hole of circular cross-section made in soil or rock.

3.1.3 *casing, n*—pipe furnished in sections with either threaded connections or bevelled edges to be field-welded, which is installed temporarily or permanently to counteract caving, to advance the borehole, or to isolate the interval being monitored, or combination thereof.

3.1.4 *caving/sloughing, n*—the inflow of unconsolidated material into an unsupported borehole that occurs when the borehole walls lose their cohesive strength.

3.1.5 *decontamination, n*—the process of removing undesirable physical or chemical constituents, or both, from equipment to reduce the potential for cross-contamination.

3.1.6 *direct push sampling, n*—sampling devices that are advanced into the soil to be sampled without drilling or borehole excavation.

3.1.7 *extension rod, n*—hollow steel rod, threaded, in various lengths, used to advance and remove samplers and other devices during direct pushing boring. Also known as *drive rod.* In some applications, small diameter solid extension rods are used through hollow drive rods to activate closed samples at depth.

3.1.8 *incremental drilling and sampling, n*—insertion method where rotary drilling and sampling events are alternated for incremental sampling. Incremental drilling often is needed to penetrate harder or deeper formations.

3.1.9 *percussion driving, n*—insertion method where rapid hammer impacts are performed to advance the sampling device. The percussion normally is accompanied with the application of a static down-force.

3.1.10 *push depth, n*—the depth below a ground surface datum to which the lower end, or tip, of the direct-push sampling device is inserted.

3.1.11 *sample interval, n*—defined zone within a subsurface strata from which a sample is gathered.

3.1.12 *sample recovery, n*—the length of material recovered divided by the length of sampler advancement and stated as a percentage.

3.1.13 *soil core, n*—cylindrical shaped specimen of sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks and which may or may not contain organic matter recovered from a soil sampler.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed barrel sampler, n*—a sampling device with a piston or other secured device that is held to block the movement of material into the barrel until the blocking device is removed or released. Liners are required in closed barrel samplers. Also may be referred to as a *protected type sampler.*

3.2.2 *impact heads/drive heads, n*—pieces or assemblies that fit to top of the above ground portion of the direct push tool assembly to receive the impact of the hammering device and transfer the impact energy to sampler extensions.

3.2.3 *open barrel sampler, n*—sampling barrel with open end allowing material to enter at any time or depth. Also may be referred to as an *unprotected type sampler.*

3.2.4 *piston lock, n*—device to lock the sampler piston in place to prevent any entry of a foreign substance into the sampler chamber prior to sampling.

3.2.5 *single tube system, n*—a system whereby single extension/drive rods with samplers attached are advanced into the subsurface strata to collect a soil sample.

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[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.6 *solid barrel sampler, n*—a soil sampling device consisting of a continuous or segmented tube with a wall thickness sufficient to withstand the forces necessary to penetrate the strata desired and gather a sample. A cutting shoe and a connecting head are attached to the barrel.

3.2.7 *split barrel sampler, n*—a soil sampling device consisting of the two half circle tubes manufactured to matching alignment, held together on one end by a shoe and on the other by a connecting head.

3.2.8 *two tube systems, n*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample. The outer tube is used for borehole stabilization. The inner tube for sampler recovery and insertion.

4. Summary of Guide

4.1 Direct push soil sampling consists of advancing a sampling device into subsurface soils by applying static pressure, by applying impacts, or by applying vibration, or any combination thereof, to the above ground portion of the sampler extensions until the sampler has been advanced to the desired sampling depth. The sampler is recovered from the borehole and the sample removed from the sampler. The sampler is cleaned and the procedure repeated for the next desired sampling interval. Sampling can be continuous for full depth borehole logging or incremental for specific interval sampling. Samplers used can be protected type for controlled specimen gathering or unprotected for general soil specimen collection.

5. Significance and Use

5.1 Direct push methods of soil sampling are used for geologic investigations, soil chemical composition studies, and water quality investigations. Examples of a few types of investigations in which direct push sampling may be used include site assessments, underground storage tank investigations, and hazardous waste site investigations. Continuous sampling is used to provide a lithological detail of the subsurface strata and to gather samples for classification and index or for chemical testing. These investigations frequently are required in the characterization of hazardous waste sites. Samples, gathered by direct push methods, provide specimens necessary to determine the chemical composition of soils, and in most circumstances, contained pore fluids (**3**).

5.2 Direct push methods can provide accurate information on the characteristics of the soils encountered and of the chemical composition if provisions are made to ensure that discrete samples are collected, that sample recovery is maximized, and that clean decontaminated tools are used in the sample gathering procedure. For purposes of this guide, "soil" shall be defined in accordance with Terminology D653. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can assure good representative samples. Direct push boreholes may be considered as a supplementary part of the overall site investigation or may be used for the full site investigation if site conditions permit. As such, they should be directed by the same procedural review and quality assurance standards that apply to other types of subsurface borings. A general knowledge of subsurface conditions at the site is beneficial.

5.3 Soil strata profiling to shallow depths may be accomplished over large areas in less time than with conventional drilling methods because of the rapid sample gathering potential of the direct push method. More site time is available for actual productive investigation as the time required for ancillary activities, such as decontamination, rig setup, tool handling, borehole backfill, and site clean-up is reduced over conventional drilling techniques. Direct push soil sampling has benefits of smaller size tooling, smaller diameter boreholes, and minimal investigative derived waste.

5.4 The direct push soil sampling method may be used as a site characterization tool for subsurface investigation and for remedial investigation and corrective action. The initial direct push investigation program can provide good soil stratigraphic information depending on the soil density and particle size, determine groundwater depth, and provide samples for field screening and for formal laboratory analysis to determine the chemical composition of soil and contained pore fluids. Use of this method, results in minimum site disturbance and no cuttings are generated.

5.5 This guide may not be the correct method for investigations in all cases. As with all drilling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. Direct push methods are not effective for solid rock and are marginally effective in partially weathered rock or very dense soils. These methods can be utilized to determine the rock surface depth. The presence or absence of groundwater can affect the performance of the sampling tools. Compact gravelly tills containing boulders and cobbles, stiff clay, compacted gravel, and cemented soil may cause refusal to penetration. Certain cohesive soils, depending on their water content, can create friction on the sampling tools which can exceed the static delivery force, or the impact energy applied, or both, resulting in penetration refusal. Some or all of these conditions may complicate removal of the sampling tools from the borehole as well. Sufficient retract force should be available to ensure tool recovery. As with all borehole advancement methods, precautions must be taken to prevent cross contamination of aquifers through migration of contaminants up or down the borehole. Regardless of the tool size, the moving of drilling and sampling tools through contaminated strata carries risks. Minimization of this risk should be a controlling factor in selecting sampling methods and drilling procedures. The user should take into account the possible chemical reaction between the sample and the sampling tool itself, sample liners, or other items that may come into contact with the sample (**3, 4**).

5.6 In some cases this guide may combine water sampling, or vapor sampling, or both, with soil sampling in the same investigation. Guides D6001 and D4700 can provide additional information on procedures to be used in such combined efforts.

6. Criteria for Selection

6.1 Important criteria to consider when selecting sampling tools include the following:

6.1.1 Size of sample.

6.1.2 Sample quality (Class A,B,C,D) for physical testing. Refer to Practice D4220.

6.1.3 Sample handling requirements, such as containers, preservation requirements.

6.1.4 Soil conditions anticipated.

6.1.5 Groundwater depth anticipated.

6.1.6 Boring depth required.

6.1.7 Chemical composition of soil and contained pore fluids.

6.1.8 Probability of cross contamination.

6.1.9 Available funds.

6.1.10 Estimated cost.

6.1.11 Time constraints.

6.1.12 History of tool performance under anticipated conditions (consult experienced users and manufacturers).

6.2 Important criteria to consider when selecting direct push equipment include the following:

6.2.1 Site accessibility.

6.2.2 Site visibility.

6.2.3 Soil conditions anticipated.

6.2.4 Boring depth required.

6.2.5 Borehole sealing requirements.

6.2.6 Equipment performance history.

6.2.7 Personnel requirements.

6.2.8 Decontamination requirements.

6.2.9 Equipment grouting capability.

6.2.10 Local regulatory requirements.

7. Apparatus

7.1 *General*—A direct push soil sampling system consists of a sample collection tool, hollow extension rods for advancement, retrieval, and transmission of energy to the sampler, and an energy source to force sampler penetration. Auxiliary tools are required to handle, assemble and disassemble, clean, and repair the sample collection tools and impact surfaces. Necessary expendable supplies are sample containers, sample container caps, sample liners, sample retainers, appropriate lubricants, and personal safety gear.

7.2 *Direct Push Tool Systems*:

7.2.1 *Two Tube System*—An outer casing and an inner extension rod with a sampler attached (see Fig. 1) are advanced simultaneously into the soil for the length capacity of the sampler. The sampler is removed from the borehole and a new sampler barrel or plug bit is inserted for each increment of depth. Two-tube sampling systems also may incorporate sample gathering chambers that are fitted into the outer casing shoe. These sample barrels are designed to create a minimum of sample disturbance while gathering high quality specimens (see Fig. 2). Samplers are held in the proper position by different methods, such as extension rods, pneumatic or mechanical packers, spring activated latches, or other devices (see Figs. 1 and 2). Locking devices must be strong enough to hold the sampler while penetrating the sample strata. The outer casing supports the borehole wall. Sample retrieval is expedited by the cased hole and continuous sampling is simplified. Continuous sampling may be a benefit to lithological logging. A cased borehole can be sealed from the bottom up as the casing is extracted (see Section 10). A cased hole may reduce the risk of contamination migration down the borehole and sample cross contamination. The two-tube system is more susceptible to soil friction because of its larger diameter and may require larger direct push energy than single-tube systems. An oversized drive shoe is sometimes used to reduce friction and buckling but may increase the risk of contamination migration down the borehole.

7.2.2 *Single Tube System*—The single tube system (see Fig. 3), uses a hollow extension/drive rod to advance and retrieve the sampler. The sampler is attached to the bottom of the extension/drive rod. A drive cap is added to the top of the extension/drive rod and the sampler is pushed into the soil. Extension/drive rods generally are smaller in diameter than the sampler. The single tube system minimizes effort for discrete interval sampling under many subsurface conditions. Tool connection time per interval is reduced. Time of removal and reinsertion of samplers into the borehole is affected by soil conditions. Repeated movement of the sampler through contaminated subsurface strata may increase the risk of contamination migration down the borehole. Bottom up borehole sealing may require re-entry in soil formations that collapse (see Section 10).

7.3 *Samplers*:

7.3.1 *Split Barrel Samplers*—Split barrel samplers (see Fig. 4) are available for use with direct push drilling methods and are available in various sizes up to 3.0 in. (76.2-mm) inside diameter. The inside tolerance should allow for use of liners. Split barrel sampler shoes used in two tube systems must be of sufficient diameter to prevent the intrusion of soil between the outer diameter of the shoe and the inside wall of the outer tube. Split barrel shoes should be replaced when the leading edge is damaged. Damaged shoes can negatively affect sample recovery. Samplers can be used with or without ball check value fitted split barrel heads. The ball check prevents uphole fluids from flowing down through the sample. Where soil sampling will be performed below the water table, the split barrel head, equipped with a ball check, should be used. The open split barrel is best used with the two tube system because the outer casing protects the borehole against cave-in or sloughing, or in soils in which the borehole wall will not collapse. Split barrel sealing systems are available. Split barrel sections can be joined to create a sampler with a nominal sample length capacity of 48 in. (1.22 m). It is understood that samplers with usable lengths beyond 24 in. (0.61 m) are used to advantage in certain soil types; however, the added weight of the soil sample in the chamber and the added friction within the sampler may prevent loose soils from entering the sampler, affecting sample recovery and representativeness. Split barrel samplers can be fitted with a basket to improve recovery in cohesionless soils. Retainers are available in many styles and materials. Retainers should allow the passage of softer soils. Stiff retainers can reduce specimen recovery in soft soils.

7.3.2 *Solid Barrel Samplers*:

7.3.2.1 *Open Solid Barrel Samplers*—Open solid barrel (see Fig. 5) samplers are used with all types of direct push sampling systems. Solid barrels can have inside diameters ranging up to 3 in. (76.2 mm). Barrel lengths range from 6 in. (152.4 mm) to 5 ft (1.53 m). Solid barrel samplers may be one piece or segmented. Sample liners should be used to facilitate removal

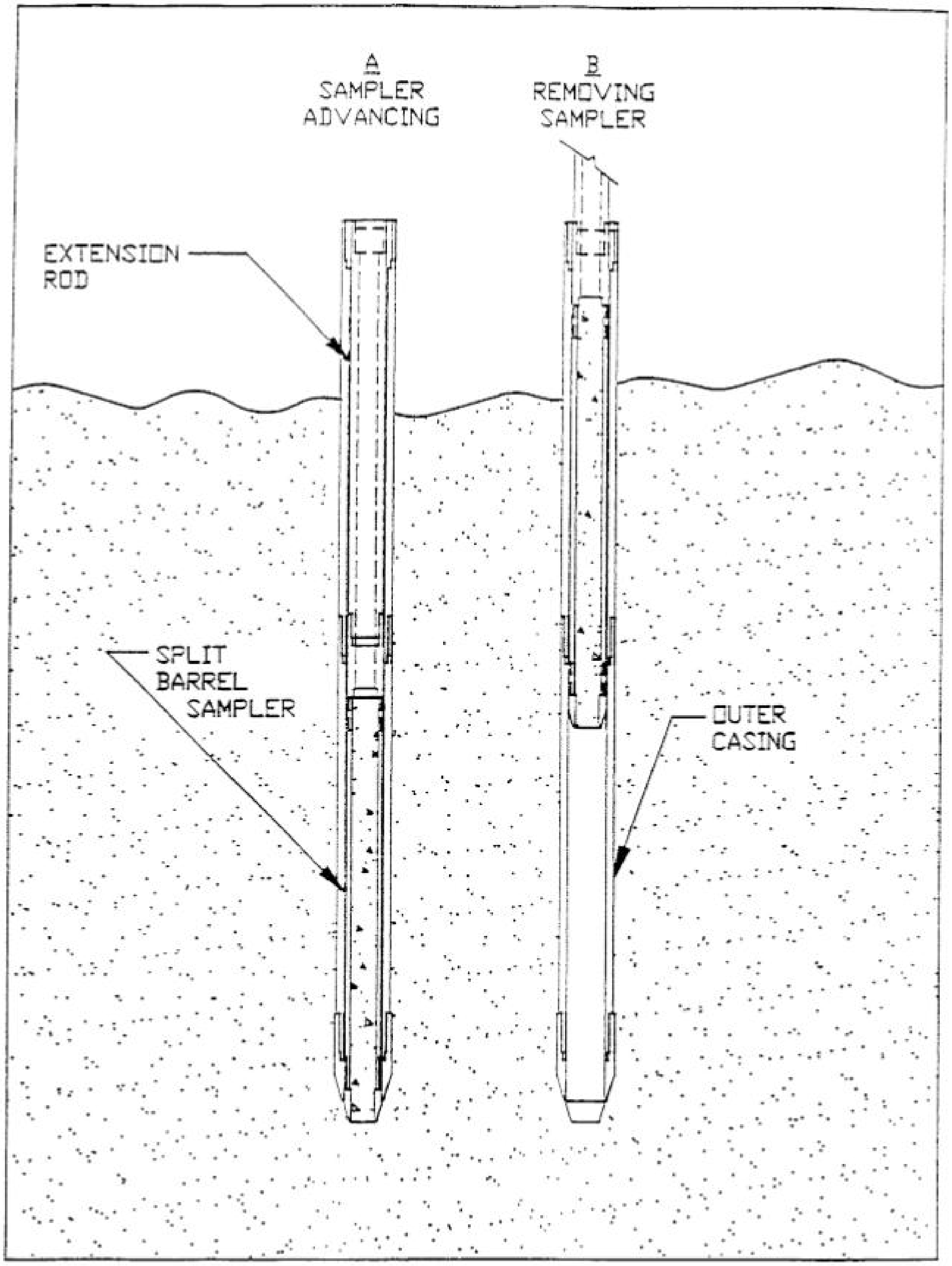

FIG. 1 Split Spoon Sampling, Two Tube System

of the sample from the solid barrel. Without the use of liners, samples are extruded mechanically. Liner lengths should fit sampler barrel lengths. Solid barrel samplers are generally assembled with a removable cutting shoe and a drive head (see Fig. 6). The head provides a backing to hold the liner stationary while the sampler is advanced and serves as a connector to the extension/drive rods. The shoe is manufactured to hold the liner stationary during the soil collection procedure. The liner should be slightly larger than the inner diameter of the cutting shoe. It may be slipped over the cutting shoe (see Fig. 6) or nested inside of the cutting shoe (see Fig. 7). The shoe is manufactured to cut the sample to a slightly undersized diameter allowing it to pass into the sample liner with a minimum of side friction to reduce sample disturbance. The amount of specimen contact with the inside of the shoe should be held to the minimum distance possible to aid in achieving the maximum amount of recovery.

7.3.3 *Closed Barrel Sampler*—Closed barrel samplers (see Figs. 2 and 3, Figs. 5-8) are devices, which remain sealed shut until an action is taken to open the sample receiving chamber. These samplers are used most often for single events (discrete point sampling) where a sealed sampler is required to avoid

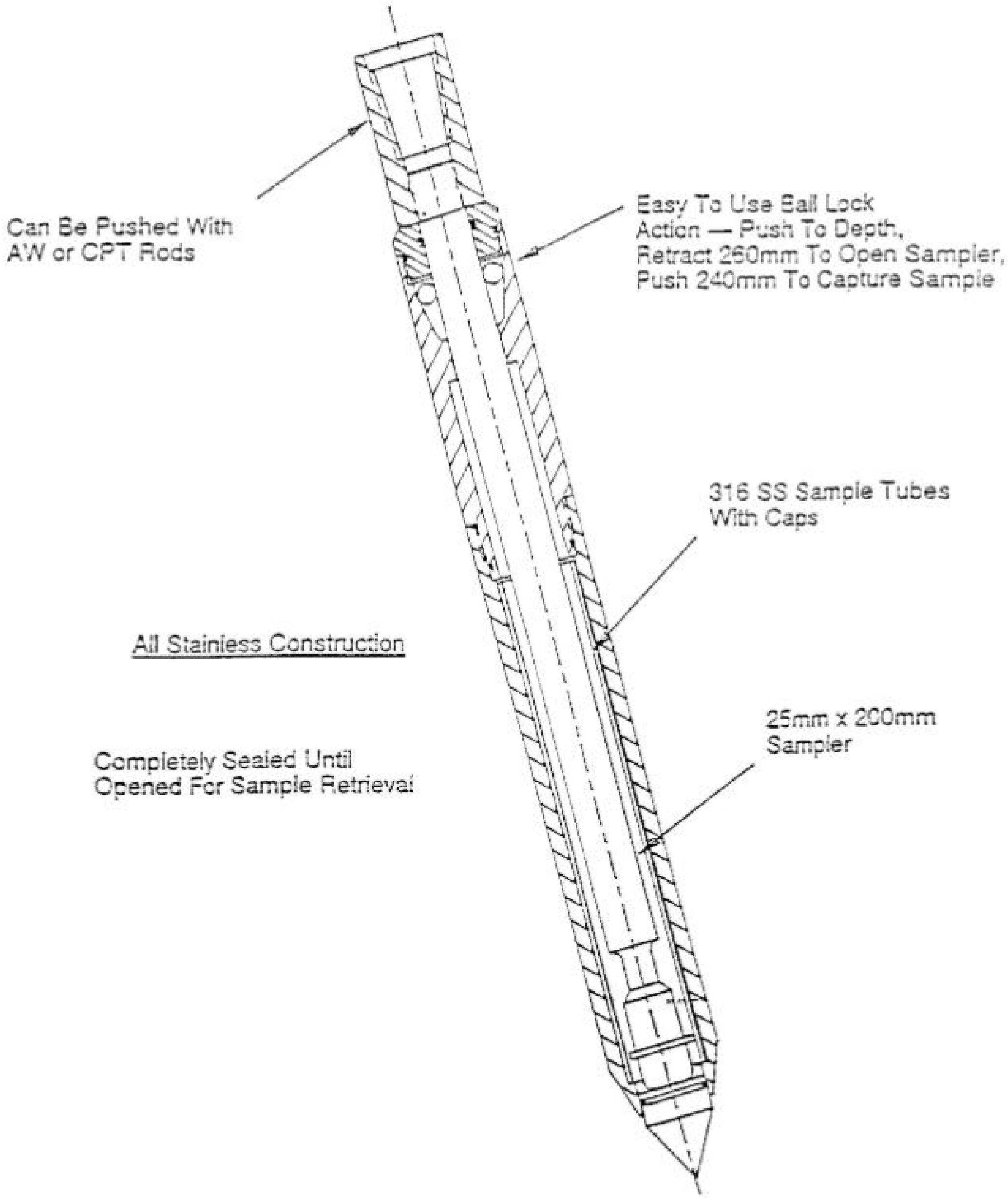

FIG. 2 Sealed Sample Barrel, Single Tube System

cross contamination or in circumstances where borehole wall stability cannot be assured. The shoe sealing device generally is a point designed to allow the continuous flow of soil around and past the sampler until such time as it is removed or released. The piston point can be fitted with seals, such as "O" rings at top and bottom to hold fluid out until sampling the desired interval. The piston rod extends through the sample retaining liner and must be released or removed for the soil to enter (see Fig. 3, Fig. 5, Fig. 7). The piston can be removed manually before sampling or be displaced by the soil entering the sampler chamber. Using the displacement method can result in reduced recovery if sampled soils do not have sufficient strength to displace the piston. Pistons are locked in place by several methods, such as a spring loaded latch. The latch holds several balls (see Fig. 2, Fig. 7, Fig. 8) into a groove in the latch coupling. When the latch is released by lifting up on the latch stem, the balls slip back into the latch chamber allowing the piston to be removed. Another method uses a locking screw. A reverse thread pin (Fig. 3, Fig. 6) is positioned in the sampler head to prevent the piston from being displaced by the soil when advancing the sampler. At the sampling interval, small diameter extension rods are inserted through the sampler extension/drive rods and rotated clockwise to unscrew the locking pin. A third method uses an inflated packer. An inflated packer (see Fig. 9) is attached to the top of the sampler barrel. The sample barrel is lowered into position in the drive casing and the packer inflated. The packer is deflated to release and the sample barrel is recovered after being advanced the sampling interval.

7.3.4 *Thin Wall Tube*—A 1.0-in. (25.4-mm) diameter thin wall tube (see Fig. 10) is available for use with direct push equipment and is manufactured according to Practice D1587. Thin wall tubes can be effective when used with dual tube direct push systems as the borehole must be kept clear of

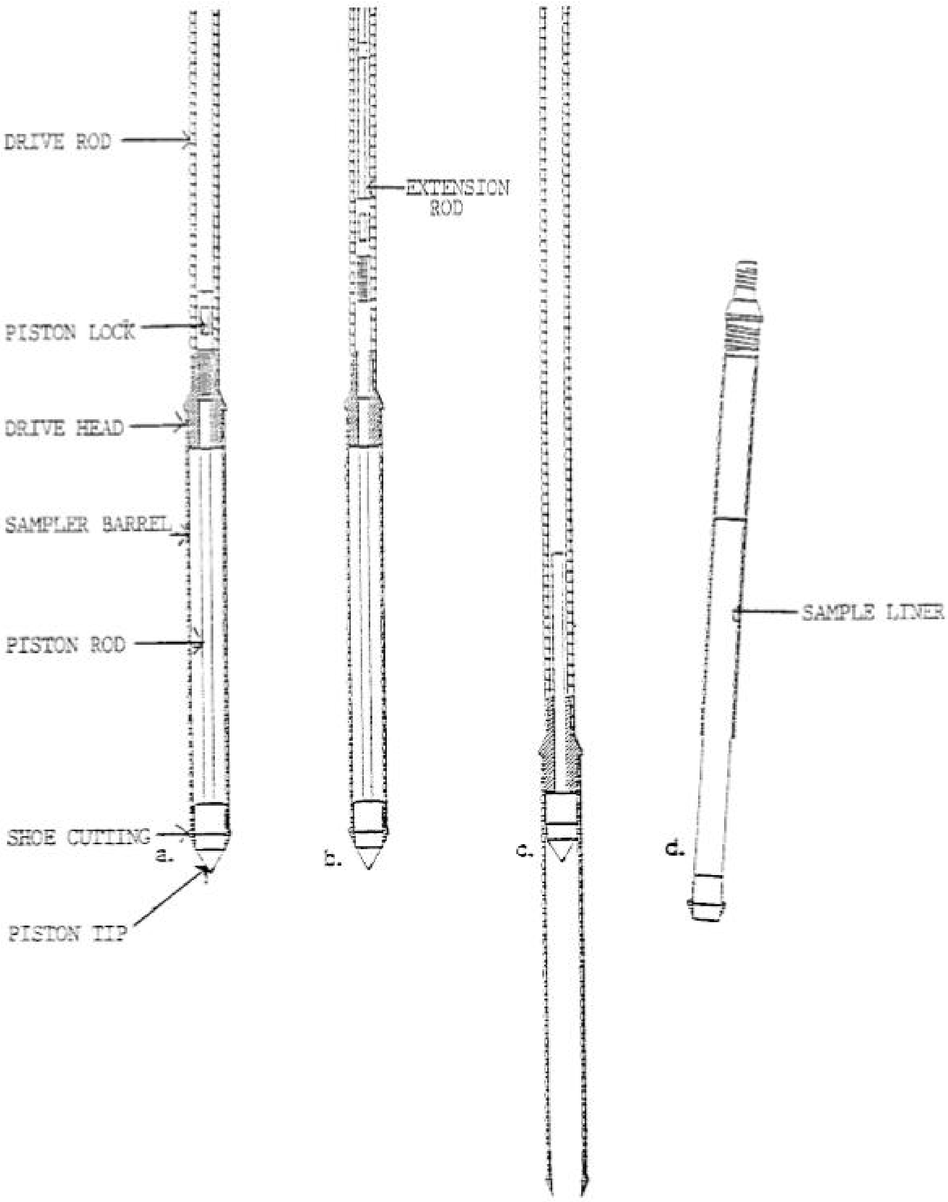

FIG. 3 Driving and Sampling, Single Tube System

(a) Driving the sealed sampler.
(b) Removing the stop-pin.
(c) Collecting a sample
(d) Recovering sample in liner.

disturbed soil prior to gathering a sample. Thin wall tubes may be effective in cohesive soils with single tube systems when the borehole can be kept clear of disturbed soil. Thin wall tubes must have an outside diameter that will allow passage through the outer casing. The thin wall tube can be operated in accordance with Practice D1587, or it can be advanced using the percussion hammer of the direct push equipment. The primary use of the thin wall tube is to gather relatively undisturbed samples in cohesive soils. Sealing of thin wall tube ends should be completed in accordance with Practice D4220. Fixed piston apparatus (see Fig. 10) also is available for use with thin walled tubes. The fixed piston action allows the sampling of very soft formations, which may not be retained in conventional samplers. In certain soil formations, the thin wall tube provides the best method to collect an undisturbed sample.

7.3.5 *Sampler Extension/Drive Rods*—Sampler extension/drive rods are lengths of rod or tube generally constructed of steel to withstand the pushing or percussion forces applied. Extension drive rods are available in various lengths. Rod lengths should be mated with casing and sampling equipment used. Thread types and classes vary between equipment manufacturers. Rod joints can be sealed to prevent fluid intrusion with "O" rings. Teflon™ washers or Teflon™ tape. Because of the percussive effort, joint seals should be checked for each sampling effort. Extension/drive rods should have sufficient inside diameter to accommodate the equipment necessary to perform the desired action.

7.3.6 *Sampler Liners*—Sampler liners are used to collect and store samples for shipment to laboratories, for field index testing of samples and for removing samples from solid barrel

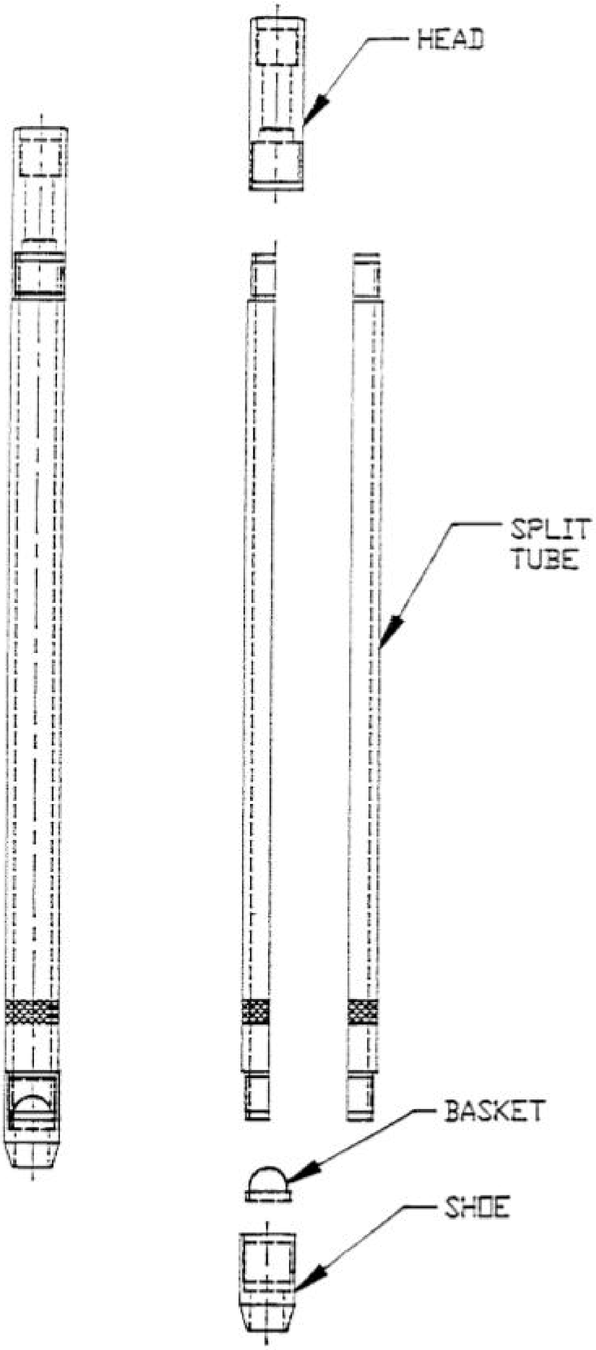

FIG. 4 Split Barrel Sampler, Two Tube System

type samplers. Liners are available in plastics, Teflon(TM), brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 in. (152.4 mm) to 5.0 ft (1.53 m). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short term as samples are subsampled and preserved immediately on site. A general rule for liner selection is stainless steel for organic compounds and plastic for metals. Teflon(TM) may be required for mixed wastes and for long time storage. Liners should be sealed in accordance with Practice D4220 when samples are collected for physical testing. Other appropriate procedures must be used when samples are collected for environmental analysis (see Practices D3694) (**1, 2**). Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners having less tolerance may be required and a shortened sampled interval used to reduce friction in the liner. Metal liners can be

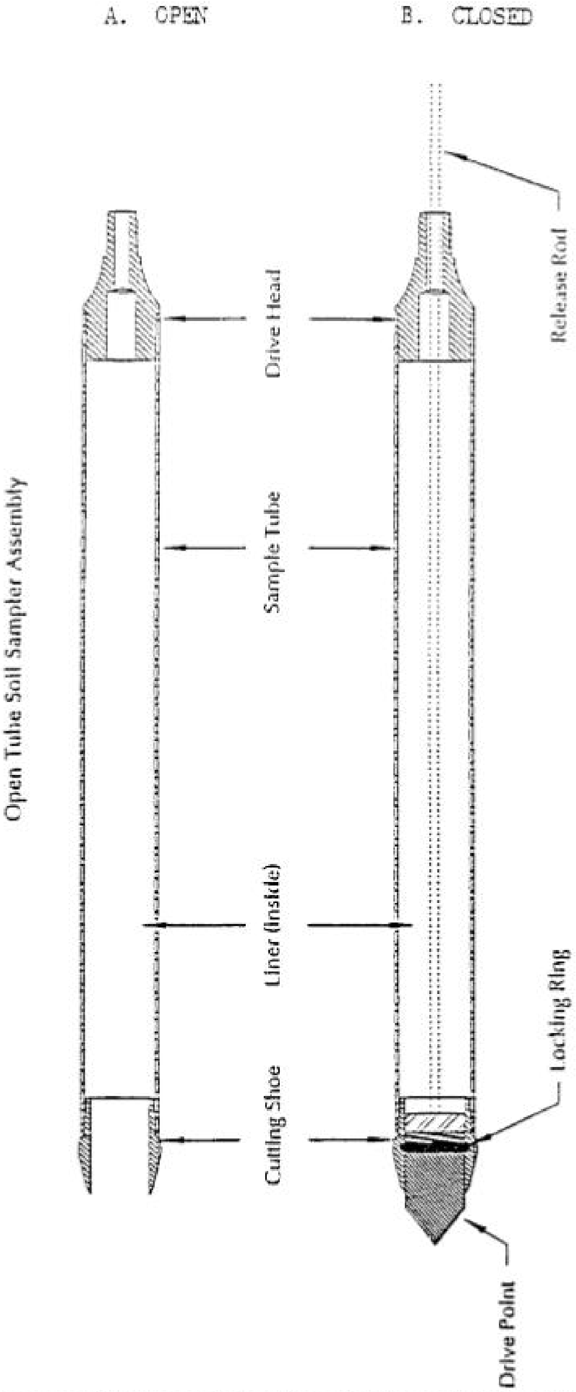

FIG. 5 (A) Open and (B) Closed Piston Sampler Assembly, Single Tube System

reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use.

7.3.7 *Sample Containers*—Sample containers should be prescribed according to the anticipated use of the sample specimen. Samples taken for chemical testing may require decontaminated containers with specific preservatives. Practice D3694 provides information on some of the special containers and preservation techniques required (**1**, **2**). These containers generally will be decontaminated to specific criteria. Samples for geotechnical testing require certain minimum volumes and specific handling techniques. Practice D4220 offers guidance for sample handling of samples submitted for physical testing.

7.4 *Direct Push Power Sources*—Soil probing percussion driving systems, penetrometer drive systems, and rotary drilling equipment may be used to drive casings and direct push soil sampling devices. The equipment should be capable of applying sufficient static force, or dynamic force, or both, to advance the sampler to the required depth to gather the desired sample. The system must have adequate retraction force to remove the sampler and extension/drive rods once the selected

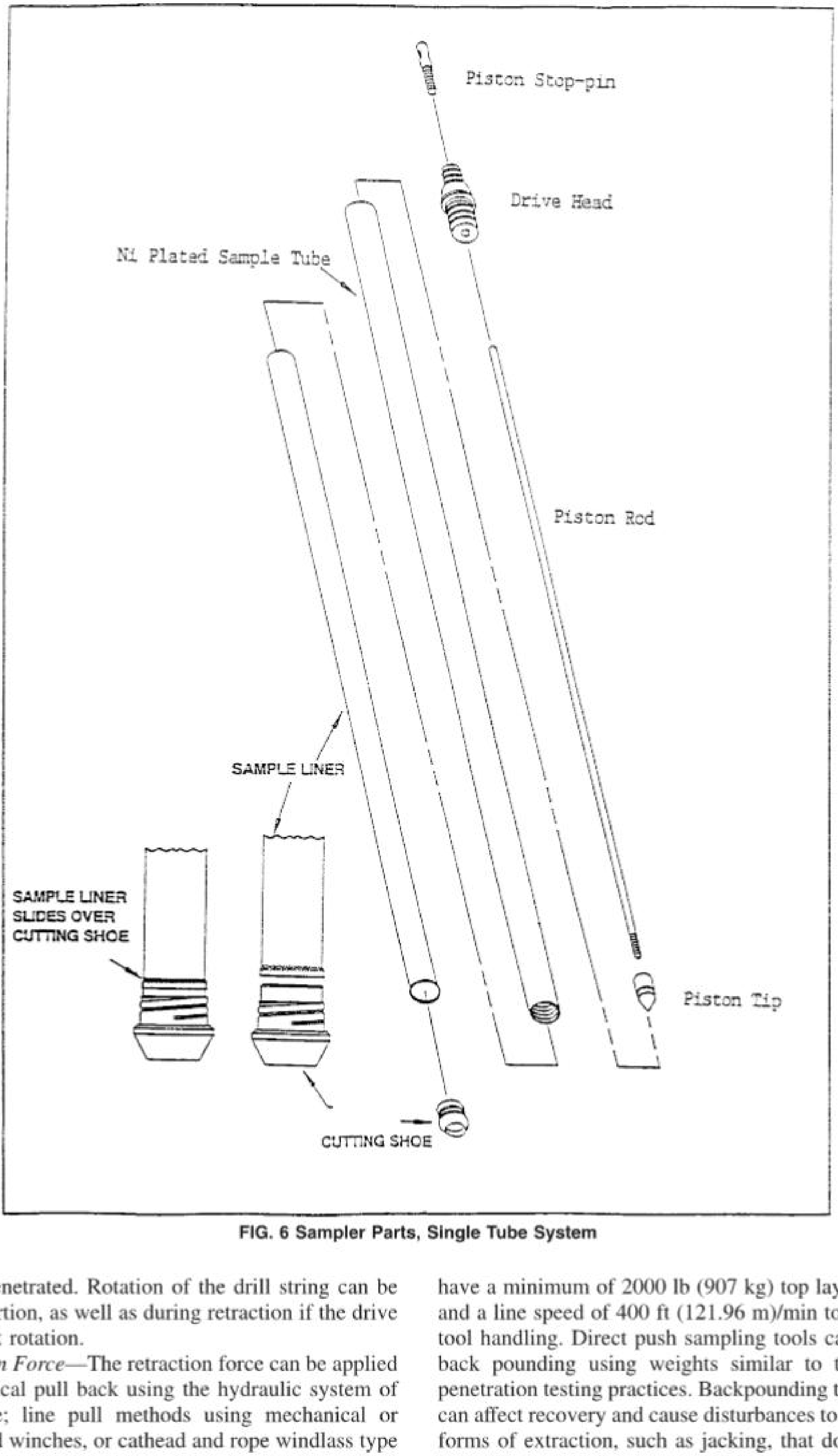

FIG. 6 Sampler Parts, Single Tube System

strata has been penetrated. Rotation of the drill string can be added during insertion, as well as during retraction if the drive system can impart rotation.

7.4.1 *Retraction Force*—The retraction force can be applied by direct mechanical pull back using the hydraulic system of the power source; line pull methods using mechanical or hydraulic powered winches, or cathead and rope windlass type devices. Winches used with direct push technology should have a minimum of 2000 lb (907 kg) top layer rating capacity and a line speed of 400 ft (121.96 m)/min to provide effective tool handling. Direct push sampling tools can be retracted by back pounding using weights similar to those of standard penetration testing practices. Backpounding to recover samples can affect recovery and cause disturbances to the sample. Other forms of extraction, such as jacking, that do not cause undue disturbance to the sample, are preferable.

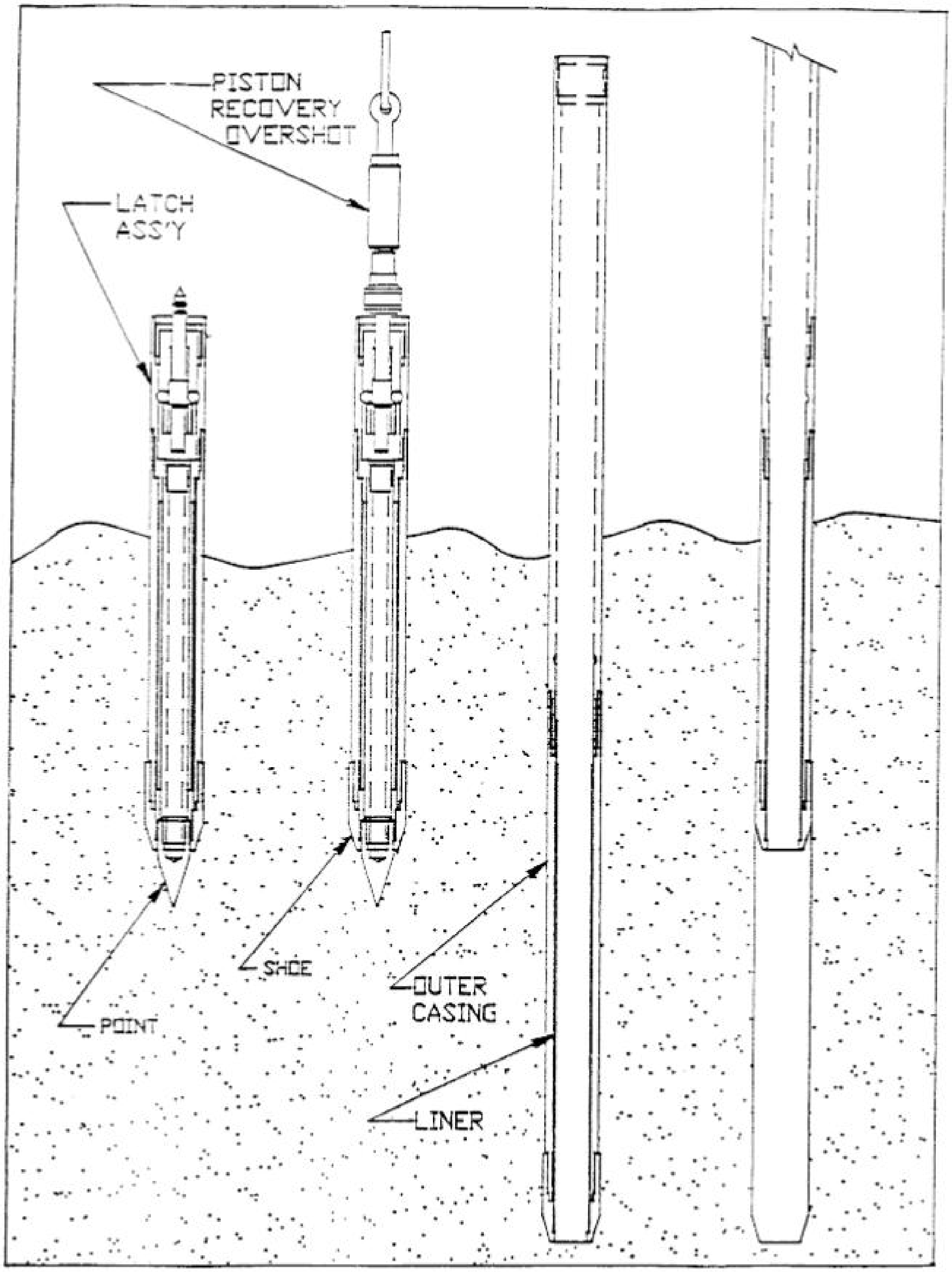

FIG. 7 Closed Solid Barrel Sampler, Single Tube System

7.4.2 *Percussion Devices*—Percussion devices for use with direct push methods are hydraulically-operated hammers, air-operated hammers, and mechanically-operated hammers. Hydraulically-operated hammers should have sufficient energy to be effective in moving the samplers through the subsurface strata. The maximum energy application is dependent on the tools used. Hammer energy that exceeds tool tolerance will result in tool damage or loss and will not achieve the goal of collecting high quality samples. Air-operated hammers should be capable of delivering sufficient energy, as well. Hammer systems utilizing hydraulic oil or air should be operated in the range specified by the manufacturer. Manually-operated hammers can be used to advance direct push tools. These hammers can be operated mechanically or manually using cathead and rope. These systems generally involve using 140 lb, standard penetration (see Test Method D1586) hammers, which can work well for direct push sampling. In operation, these hammers tend to be slower than hydraulic hammers and can cause tool damage if direct push tools are not designed to take the heavy blows associated with these hammers. The hydraulic- and air-operated hammers strike up to 2000 blows/min. In addition to the energy transferred, the rapid hammer

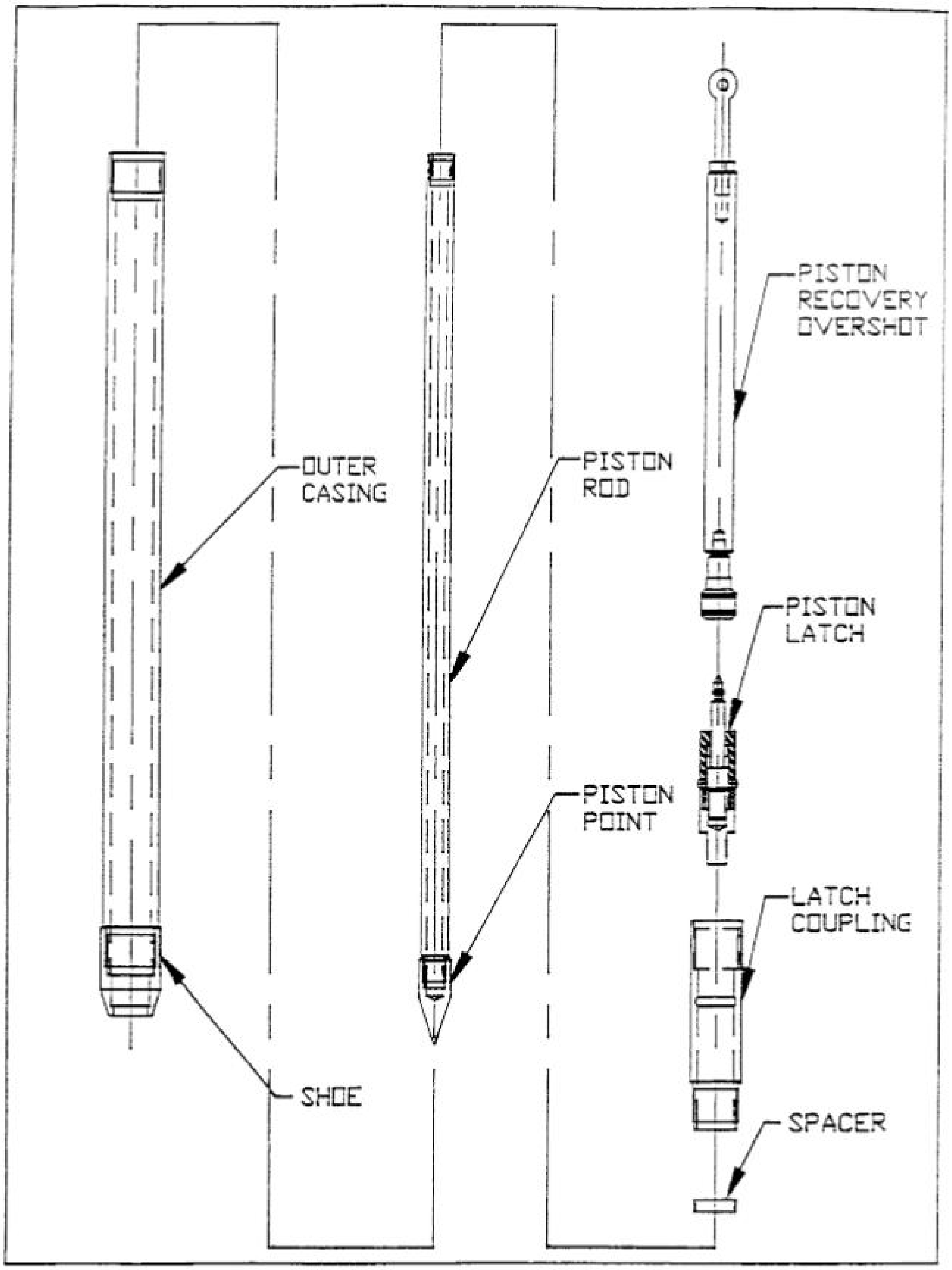

FIG. 8 Closed Solid Barrel Sampler, Single Tube System

action sets up a vibratory effect, which also aids in penetration. This vibratory effect, along with the percussive effort, may disturb some soil samples.

7.4.3 *Static Push Systems*—Cone penetrometer systems are an example of static push systems. They impart energy to the sampler and extension rods by using hydraulic rams to apply pressure. The pressure applied is limited to the reactive weight of the drive vehicle. Retraction of the sampler and extension rods is by static pull from the hydraulic rams.

7.4.4 *Vibratory/Sonic Systems*—These systems utilize a vibratory device, which is attached to the top of the sampler extension rods. Reactive pressure and vibratory action are applied to the sampler extensions moving the sampler into the formation. In certain formations, sample recovery and formation penetration is expedited; however, all formations do not react the same to vibratory penetration methods.

7.4.4.1 *Sonic or Resonance Drilling Systems*—These are high powered vibratory systems that can be effective in

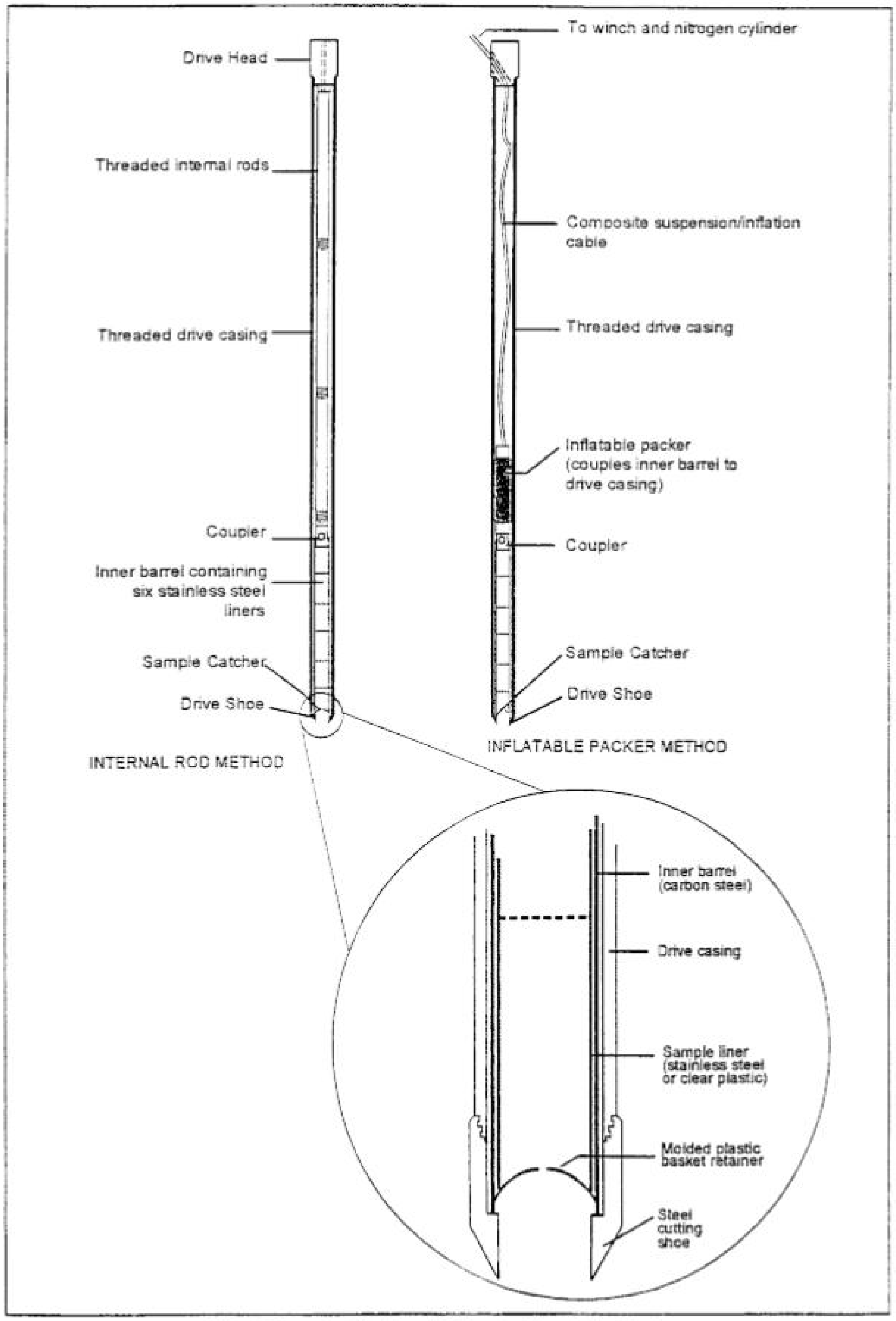

FIG. 9 Sampler Holding Methods, Two Tube System

advancing large diameter single or dual tube systems. They generally have depth capabilities beyond the smaller direct push systems.

7.4.5 *Rotary Drilling Equipment*—Direct push systems are readily adaptable to rotary drill units. The drill units offer a ready hydraulic system to operate percussion hammers, as well as reactive weight for static push. Because most drills are equipped with leveling jacks, better weight application is achieved. Vertical pushing is improved because of the ability to level the machine. Tool handling is facilitated by high speed winches common to drilling rigs, extended masts for long tool pulls, and longer feed stroke length. Drill units with direct push adaptations also offer drilling techniques should obstacles be encountered while using direct push technology. Large drill units may have reactive weights that can exceed the tool capacity, thereby resulting in damaged tools.

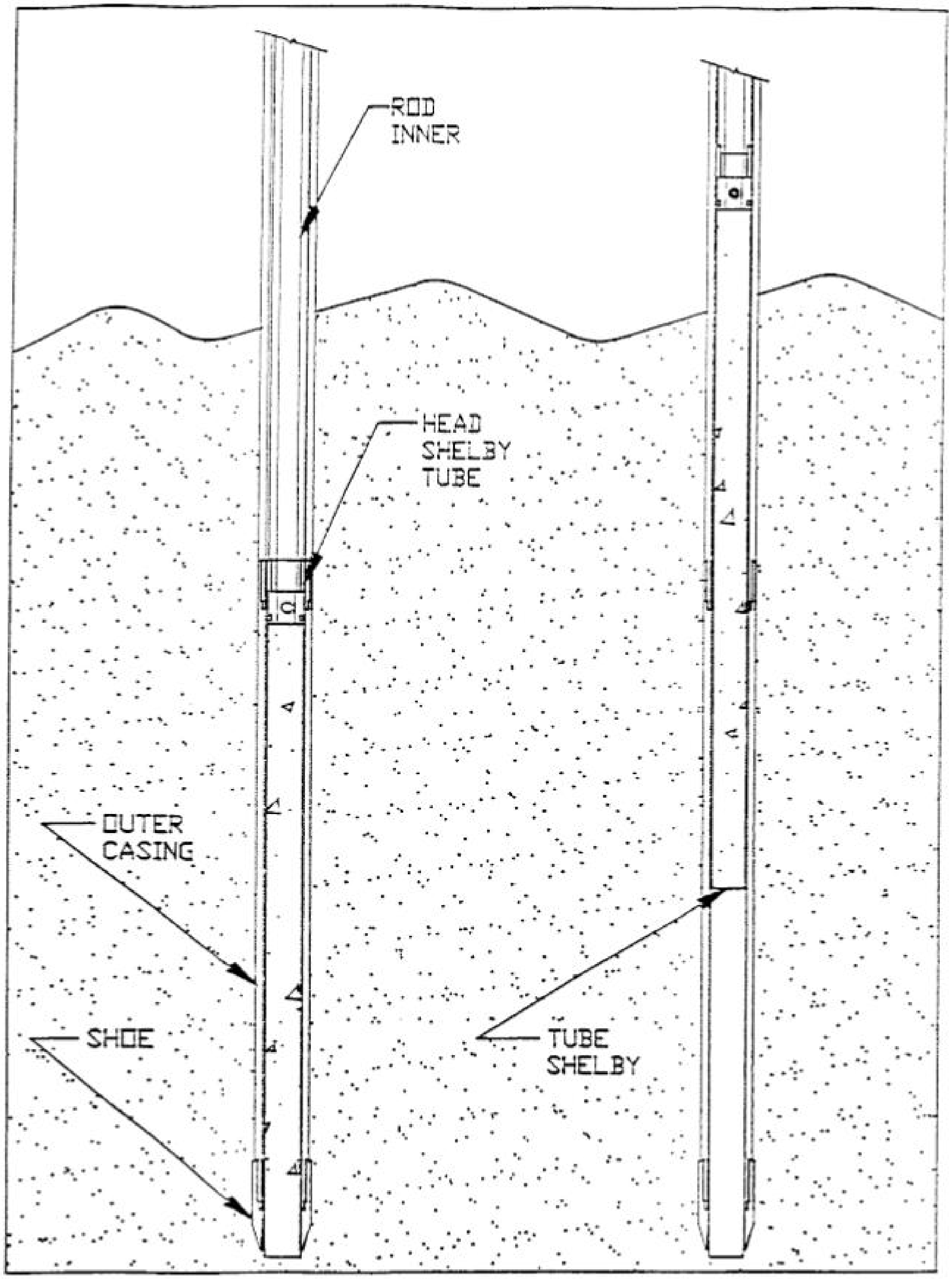

FIG. 10 Thin Wall Tube Sampler, Two Tube System

8. Conditioning

8.1 *Decontamination*—Sampling equipment that will contact the soil to be sampled should be cleaned and decontaminated before and after the sampling event. Extension rods should be cleaned prior to each boring to avoid the transfer of contaminants and to ease the connecting of joints. Thread maintenance is necessary to ensure long service life of the tools. Sample liners should be kept in a sealed or clean environment prior to use. Reusable liners should be decontaminated between each use. All ancillary tools used in the sampling process should be cleaned thoroughly, and if contaminants are encountered, decontaminated before leaving the site. It should not be assumed that new tools are clean. They should be cleaned and decontaminated before use. Decontamination should be performed following procedures outlined in Practice D5088 along with any site safety plans, sampling protocols, or regulatory requirements.

8.2 *Tool Selection*—Prior to dispatch to the project site an inventory of the necessary sampling tools should be made. Sample liners, containers, sampling tools, and ancillary equipment should be checked to ensure its proper operation for the work program prescribed. Sampling is expedited by having two or more samplers on site. Since samples can be recovered quite fast, a supply of samplers will allow a boring to be completed so other functions can be performed while samples are being processed. A backup tool system adaptable to and within the capabilities of the power source should be available should the original planned method prove unworkable. Materials for proper sealing of boreholes should always be available at the site (**5-7**).

9. Procedure

9.1 While procedures for direct push soil sampling with two common direct push methods are outlined here, other systems may be available. As long as the basic principles of practice relating to sampler construction and use are followed, other systems may be acceptable.

9.2 *General Set-Up*—Select the boring location and check for underground and overhead utilities and other site obstructions. Establish a reference point on the site for datum measurements, and set the direct push unit over the boring location. Stabilize and level the unit, raise the drill mast or frame into the drilling position, and attach the hammer assembly to the drill head if not permanently attached. Attach the anvil assembly in the prescribed manner, slide the direct push unit into position over the borehole, save a portion of the sliding distance for alignment during tool advancement, and ready the tools for insertion.

9.2.1 *Tool Preparation*—Inspect the direct push tools before using, and clean and decontaminate as necessary. Inspect drive shoes for damaged cutting edges, dents, or thread failures as these conditions can cause loss of sample recovery and slow the advancement rate. Where permissible, lubricate rod joints with appropriate safe products, and check impact surfaces for cracks or other damage that could result in failure during operations. Assemble samples and install where required, install sample retainers where needed, and install and secure sampler pistons to ensure proper operation where needed.

9.2.2 *Sample Processing*—Sample processing should follow a standard procedure to ensure quality control procedures are completed. View sample in the original sampling device, if possible. Open the sampling device with care to keep disturbance to a minimum. When using liners or thin wall tubes, protect ends to prevent samples from falling out or being disturbed by movement within the liner. Measure recovery accurately, containerize as specified in the work plan or applicable ASTM procedures, and label recovered samples with sufficient information for proper identification. When collecting samples for volatile chemical analysis, sample specimens must be contained and preserved as soon as possible to prevent loss of these components. Follow work plan instructions or other appropriate documents (see Practice D3694) when processing samples collected for chemical analysis.

9.3 *Two Tube System*:

9.3.1 *Split Barrel Sampling (see Fig. 1)*—Assemble the outer casing with the drive shoe on the bottom, attach the drive head to the top of the outer casing, and attach the sampler to the extension rods. Connect the drive head to the top of the sampler extension rods, and insert the sampler assembly into the outer casing. The sampler cutting shoe should contact the soil ahead of the outer casing to prevent unnecessary sample disturbance. The split spoon cutting shoe should extend a minimum of 0.25 in. (6.25 mm) ahead of the outer casing. Greater extensions may improve recovery in soft formations. Mark the outer casing to designate the required drive length, position the outer casing and sampler assembly under the drill head, and move the drill head downward to bring pressure on the tool string. If soil conditions allow, advance the sampler/casing assembly into the soil at a steady rate slow enough to allow the soil to be cut by the shoe and move up inside the sample barrel. If advancement is too rapid, it can result in loss of recovery because of soil friction in the shoe. Occasional hammer action during the push may help recovery by agitating the sample surface. If soil conditions prevent smooth static push advancement, activate the hammer to advance the sampler. Apply a continuous pressure while hammering to expedite soil penetration. The pressure required is controlled by subsurface conditions. Applications of excessive down pressure may result in the direct push unit being shifted off the borehole causing misalignment with possible tool damage. Stop the hammer at completion of advancement of the measured sampling barrel length. Release the pressure and move the drill head off the drive head. Attach a pulling device to the extension rods or position the hammer bail and retrieve the sampler from the borehole. At the surface remove the sampler from the extension rods and process. Soil classification is accomplished easily using split barrel samplers as the specimen is available readily for viewing, physical inspection and subsampling when the barrel is opened. Clean, decontaminate, and reassemble the sampler. Reattach the sampler to the extension rod, add the necessary extension rod and outer casing to reach the next sampling interval, and sound the borehole for free water before each sample interval. If water is present, it may be necessary to change sampling tools. Unequal pressure inside the casing may result in blow-in of material disturbing the soil immediately below the casing. Lower the sampler to its proper position, add the drive heads, and repeat the procedure. If it is desired that the pass through certain strata without sampling, install an extension rod point in lieu of the sampler. When the sampling interval is reached, remove the point and install the sampler. Advance the sampler as described. Upon completion of the borehole, remove the outer casing after instrumentation has been set or as the borehole is sealed as described in Section 10 (**6**).

9.3.2 *Two Tube System—Other Samplers*:

9.3.2.1 *Thin Wall Tubes*—Thin wall tubes (see Fig. 10) can be used with the dual tube system. Attach the tube to the tube head using removable screws. Attach the tube assembly to the extension rods and position at the base of the outer casing shoe protruding a minimum of 0.25 in. (6.25 mm) to contact the soil ahead of the outer casing. Advance the tube, with or without the outer casing, at a steady rate similar to the requirements of Practice D1587. At completion of the advancement interval, let the tube remain stationary for 1 min. Rotate the tube slowly two revolutions to shear off the sample. Remove the tube from the borehole, measure recovery, and classify soil. The thin wall tube can be field extruded for on-site analysis or sealed in accordance with Practice D4220 and sent to the laboratory for processing. Samples for environmental testing generally require the subsampling and preservation of samples in controlled containers. Soil samples generally are removed from the sampling device for storage and shipping. Thin wall tubes should be cleaned and decontaminated before and after use.

9.3.2.2 *Thin Wall Tube Piston Sampler (see Fig. 11)*—Check the fixed piston sampling equipment for proper operation of the cone clamping assembly and the condition of the sealing "O" rings. Slide the thin wall tube over the piston, and attach it to the tube head. Position the piston at the sharpened end of the thin wall tube just above the sample relief bend. Attach the sampler assembly to the extension rods, and lower the sampler into position through the outer casing. Install the actuator rods through the extension rod, and attach to the actuator rod in the sampler assembly. Attach a holding ring to the top of the actuator rod string, and hook the winch cable or other hook to the holding ring to hold the actuator rods in a fixed position. Attach the pushing fork to the drill head/probe hammer, and slowly apply downward pressure to the extension rods advancing the thin wall tube over the fixed piston into the

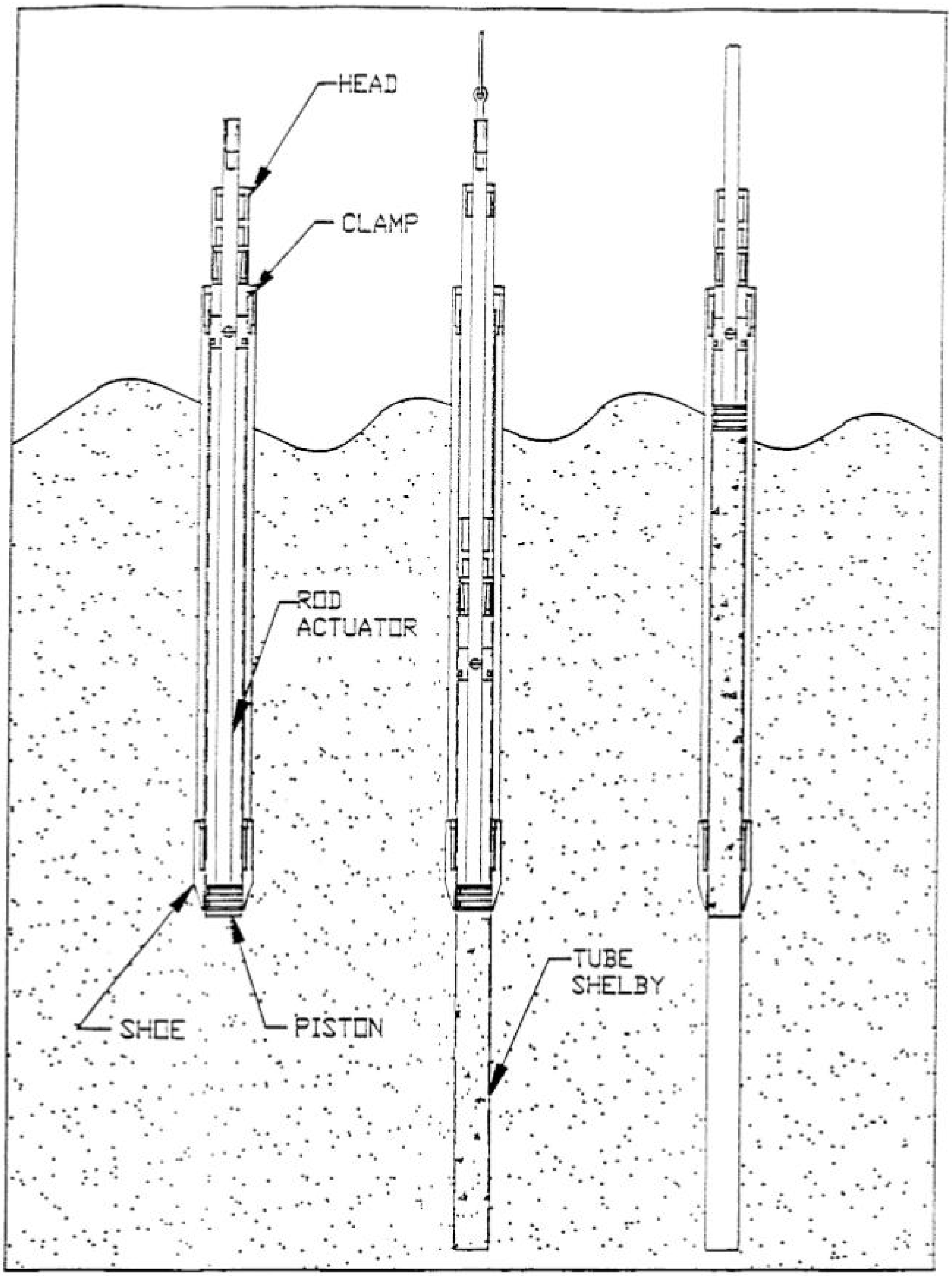

FIG. 11 Fixed Piston Sampler, Two Tube System

soil for the sample increment. Rest sampler 1 min to allow sample to conform to tube. Rotate tube one revolution to shear off sample. Remove sampler assembly from borehole and process sample (**6**).

9.3.2.3 *Open Solid Barrel Samplers*—Use solid barrel samplers in advance of the outer casing where the soil conditions could cause swelling of split barrel samplers, or where friction against the outer casing precludes its advancement and sampling must still be accomplished. The solid, single, or segmented barrel sampler requires the use of liners for removal of the sample. The sampler must be cleaned and decontaminated before use. Use of the sampler follows the procedure described in 9.3.1.

9.4 *Single Tube System*:

9.4.1 *Open Solid Barrel Sampler (see Figs. 5 and 6)*—Attached the required liner to the cutting shoe by insertion into the machined receptacle area or by sliding over the machined tube. Insert the liner and shoe into the solid barrel, and attach the shoe (**6, 8-11**). Attach the sampler head to the sampler barrel providing a backing plate for the liner. Attach the sampler assembly to the drive rod and the drive head to the drive rod. Position the assembly under the hammer anvil and advanced as described in 9.3.1. At completion of the sampling increment, remove the sampler from the borehole. Remove the filled sample liner from the barrel by unscrewing the shoe, cap the liner for laboratory testing or spit open for field processing, and advance the borehole by repeating the procedure. Because the solid barrel cannot be opened for cleaning, it may require more effort for cleaning and decontamination. The open solid barrel sampler is used in soil formations that have sufficient wall strength to maintain a borehole wall without sloughing or cave-in. In soil formations not affording such structure, other sampling methods may be required or the opening sealed. To enhance recovery in some soil strata, it may be necessary to vary the length of the sampling increment. Shorter increments generally improve recovery because of lower sample friction and compression inside the sampler chamber. Sample recovery can be enhanced in some formations by intermittent use of the percussion hammer (**6, 8, 10, 11**).

9.4.2 *Closed Solid Barrel Sampler (see Figs. 5-7, Fig. 11)*—Insert or attach the sample liner to the shoe, and insert the assembly into the solid barrel sampler. Install sample retaining basket if desired. Attach the latch coupling or sampler head to the sampler barrel, and attach the piston assembly with point and" O" rings if free water is present, to the latching mechanism or holder. Insert the piston or packer into the liner to its proper position so the point leads the sampler shoe. Set latch, charge packer, or install locking pin, and attach assembled sampler to drive rod. Add drive head and position under the hammer anvil. Apply down pressure, hammer if needed, to penetrate soil strata above the sampling zone. When the sampling zone is reached, insert the piston latch release and recovery tool, removing the piston, or insert the locking pin removal/extension rods through the drive rods, turn counterclockwise, and remove the piston locking pin so the piston can float on top of the sample, or release any other piston holding device. Direct push or activate the hammer to advance the sampler the desired increment. Retrieve the sampler from the borehole by withdrawing the extension/drive rods. Remove the shoe, and withdraw the sample liner with sample for processing. Clean and decontaminate the sampler, reload as described, and repeat the procedure. Extreme stress is applied to the piston when driving through dense soils. If the piston releases prematurely, the sample will not be recovered from the correct interval, and a resample attempt must be made. The piston sampler can be used as a re-entry grouting tool for sealing boreholes on completion if it is equipped with a removable piston (**5, 6, 7, 10, 11**).

9.4.3 *Standard Split Barrel Sampler*—Attach the split spoon to an extension rod or drill rod. Using a mechanical or hydraulic hammer drive the sampler into the soil the desired increment, as long as that increment does not exceed the sampler chamber length. Remove the sampler from the borehole, disassemble, and process sample. Standard split barrel samplers can be used, as long as borehole wall integrity can be maintained and the additional friction can be overcome. If caving or sloughing occurs, the sampler tip should be sealed or other sampling tools used (**9**).

9.5 *Quality Control*:

9.5.1 *Quality Control*—Quality control measures are necessary to ensure that sample integrity is maintained and that project data quality objectives are accomplished. By following good engineering principles and applying common sense, reliable site characterizations can be accomplished.

9.5.2 *Water Checks*—Water seeping into the direct push casing or connecting rods from contaminated zones may influence testing results. Periodically check for groundwater before inserting samplers into borehole or into outer casings in the two tube system. If water is encountered, it may be necessary to switch to the sealed piston type samplers to protect sample integrity. Sealed piston type samples may not always be water tight. Sealing of rod or casing joints can prevent groundwater from entering through the joints.

9.5.3 *Datum Points*—Establishment of a good datum reference is essential to providing reliable sample interval depths and elevators. Select datum reference points that are sufficiently protected from the work effort, and that can be located for future reference. Field measurements should be to 0.1 ft (3.05 mm). Measure extension rods as the bore advances to locate sample depth. Mark rods before driving each sample interval to determine accurate measurement of sample recovery and to accurately log borehole depth.

9.5.4 *Sample Recovery*—Sample recovery should be monitored closely and results documented. Poor recovery could indicate a change in sampling method is needed, that improper sampling practices are being conducted, or that sampling tools are incorrect. Sample recovery involves both volume and condition. Poor sample recovery should cause an immediate review of the sampling program.

9.5.5 *Decontamination*—Follow established decontamination procedures. Taking shortcuts may result in erroneous or suspect data.

10. Completion and Sealing

10.1 *Completion*—For boreholes receiving permanent monitoring devices, completion should be in accordance with Practice D5092, site work plan, or regulatory requirements.

10.2 *Borehole Sealing*—Seal direct push boreholes to minimize preferential pathways for containment migration. Additional information and guidance on borehole sealing can be found in Guide D6001 and in Guide D5299. State or local regulations may control both the method and the materials for borehole sealing. Regulations generally direct bottom up borehole sealing as it is the surest and most permanent method for complete sealing. High pressure grouting is available for use with direct push technology for bottom up borehole sealing.

10.2.1 *Sealing by Slurry, Two Tube System*—Sound the borehole for free water. If water exists in the casing, place the extension rods, open-ended, to the bottom of the outer casing, as a tremie. Mix the slurry to standard specifications prescribed by regulation or work plan. Pump slurry through the extension/drive rod until it appears at the surface of the outer casing. Remove the extension rods. If no free water exists in the borehole, the slurry can be placed by gravity. Top off the outer casing as it is removed from the borehole.

10.2.1.1 *Slurry Mixes*—Slurry mixes used for slurry grouting of direct push boreholes generally are of lower viscosity because of the small diameter tremie pipes required. Usable mixes are 6 to 8 gal (22.7 to 30.28 L) of water/94-lb (42.64-kg) bag of cement with 5 lb (2.27 kg) of bentonite or 24 to 36 gal (90.84 to 136.28 L) of water to 50 lb (22.68 kg) of bentonite.

10.2.2 *Sealing by Gravity—Two Tube System*—Measure the cased hole to ensure it is open to depth. Slowly add bentonite chips or granular bentonite to fill the casing approximately 2 ft. Withdraw the casing 2 ft and recheck depth. Hydrate the bentonite by adding water. Repeat this procedure as the outer casing is withdrawn. The bentonite must be below the bottom of the casing during hydration. Wetness inside the rods may affect the flow of granular bentonite to the bottom of the casing. Fill the top foot of the borehole with material that is the same as exists in that zone.

10.2.3 *Borehole Sealing Single Tube System*:

10.2.3.1 *Gravity Sealing from Surface*—If the soil strata penetrated has sufficient wall strength to maintain an open hole, then it may be possible to add sealing materials from the surface. Dry bentonite chips or granular bentonite can be placed by gravity. The borehole volume should be determined and the borehole sounded every 10 ft (3 m) to ensure bridging has not occurred. The bentonite should be hydrated by adding approximately 1 pt (0.57 L) of water for each 5 ft of filled borehole. Seal the surface with native material.

10.2.3.2 *Wet Grout Mix Tremie Sealing*—Tremie sealing methods can be used with single tube systems when borehole wall strength is sufficient to maintain an open hole or when extension rods with an expendable point are used to reenter the borehole. The grout pipe should be inserted immediately after the direct push tools are withdrawn or through the annulus of the extension rods that have been reinserted down the borehole for grouting. Care must be taken to not plug the end of the grout pipe. Side discharge grout pipes also can be used to prevent plugging.

10.2.4 *Re-Entry Grouting*—If the borehole walls are not stable, the borehole can be re-entered by static pushing grouting tools, such as an expendable point attached to the extension/drive rods to the bottom of the original borehole. Pump a slurry through the rods as they are withdrawn. High pressure grouting equipment may be beneficial in pumping standard slurry mixes through small diameter gravity pipes. Care must be taken to ensure the original borehole is being sealed.

11. Record Keeping

11.1 *Field Report*—The field report may consist of boring log or a report of the sampling event and a description of the sample. Soil samples can be classified in accordance with Practice D2488 or other methods as required for the investigation **(12)**. Prepare the log in accordance with standards set in Guide D5434 listing the parameters required for the field investigation program. List all contaminants identified, instrument readings taken, and comments on sampler advancement. Record any special field tests performed and sample processing procedures beyond those normally used in the defined investigation. Record borehole sealing procedures, materials used, and mix formulas on the boring log. Survey or otherwise locate the boring site to provide a permanent record of its replacement.

11.2 *Backfilling Record*—Record the method of sealing, materials used, and volume of materials placed in each borehole. This information can be added to the field boring log or recorded on a separate abandonment form.

12. Keywords

12.1 decontamination; direct push; groundwater; sealing; soil sampling

REFERENCES

(1) Ford, Patrick J., and Turine, Paul J., *"Characterization of Hazardous Waste Sites—A Methods Manual" Vol II, Available Sampling Methods*, Second Edition, (Appendix A: Sample Containerization and Preservation), December 1984, EPA-600/4-84-076.

(2) Mayfield, D., Waugh, J., and Green, R., " *Environmental Sampling Guide in Environmental Testing and Analysis Product News*, Vol 1, No. 1, April 1993.

(3) McLoy and Associates, Inc. "Soil Sampling and Analysis—Practice and Pitfalls," *The Hazardous Waste Consultant*, Vol 10, Issue 6, 1992.

(4) Kay, J. N., "Technical Note," *"Symposium on Small Diameter Piston Sampling with Cone Penetrometer Equipment*," ASTM, 1991.

(5) Einearson, M.D., *"Wire Line Sample Recovery System,"* Precision Sampling Incorporated, San Fafael, CA, 1995.

(6) Ruda, T.C., "Operating the Diedrich Drill ESP System Tools," LaPorte, IN, 1995.

(7) Sales Division, "GS-1000 Series Grout System," Geoprobe System, 1996.

(8) Sales Division, "Catalogue of Products," Geoprobe, Inc., Standard Operating Procedures, Technical Bulletin No. 93-660, 1993.

(9) Sales Division, "Catalogue of Products," Diedrich Drill, Inc., LaPorte, IN, 1995.

(10) Sales Division, "Geoprobe Macro-Core Soil Sampler, Standard Operating Procedure," Technical Bulletin No. 95–8500, November 1995.

(11) Sales Division, "Geoprobe AT-660 Series Large Bore Soil Sampler, Standard Operating Procedures," Technical Bulletin No. 93–660, Revised: June 1995.

(12) Boulding, J.R., *"Description and Sampling of Contaminated Soils: A Field Pocket Guide,"* EPA-625/12-91/002; 1991 (second edition published in 1994 by Lewis Publishers).

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B-6

Canister Sampling Methodology

Designation: D 5466 – 01 (Reapproved 2007)

Standard Test Method for Determination of Volatile Organic Chemicals in Atmospheres (Canister Sampling Methodology)[1]

This standard is issued under the fixed designation D 5466; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a procedure for sampling and analysis of volatile organic compounds (VOCs) in ambient, indoor, or workplace atmospheres. The test method is based on the collection of air samples in stainless steel canisters with specially treated (passivated) interior surfaces. For sample analysis, a portion of the sample is subsequently removed from the canister and the collected VOCs are selectively concentrated by adsorption or condensation onto a trap, subsequently released by thermal desorption, separated by gas chromatography, and measured by a mass spectrometric detector or other detector(s). This test method describes procedures for sampling into canisters to final pressures both above and below atmospheric pressure (respectively referred to as pressurized and subatmospheric pressure sampling).[2]

1.2 This test method is applicable to specific VOCs that have been tested and determined to be stable when stored in canisters. Numerous compounds, many of which are chlorinated VOCs, have been successfully tested for storage stability in pressurized canisters (**1-4**).[3] Although not as extensive, documentation is also available demonstrating stability of VOCs in subatmospheric pressure canisters. While initial studies were concentrated on non-polar VOCs, information on storage stability has been extended to many polar compounds as well (**5-7**).

1.3 The procedure for collecting the sample involves the use of inlet lines and air filters, flow rate regulators for obtaining time-integrated samples, and in the case of pressurized samples, an air pump. Canister samplers have been designed to automatically start and stop the sample collection process using electronically actuated valves and timers (**8-10**). A weatherproof shelter is required if the sampler is to be used outside.

1.4 The organic compounds that have been successfully measured at single-digit parts-per-billion by volume (ppbv) levels with this test method are listed in Table 1. This test method is applicable to VOC concentrations ranging from the detection limit to 300 ppbv. Above this concentration, samples require dilution with dry ultra-high-purity nitrogen or air.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Safety practices should be part of the user's SOP manual.*

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres

D 1357 Practice for Planning the Sampling of the Ambient Atmosphere

E 260 Practice for Packed Column Gas Chromatography

E 355 Practice for Gas Chromatography Terms and Relationships

2.2 *Other Documents:*

U.S. Environmental Protection Agency, Compendium of Methods for the Determination to Toxic Organic Compounds in Ambient Air, Method TO-14A, EPA 600/R-96/010b [5]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D 1356. Other pertinent abbreviations and symbols are defined within this practice at point of use.

3.2 *Definitions of Terms Specific to This Standard:*

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[1] This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.05 on Indoor Air.

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[2] This test method is based on EPA Compendium Method TO-14, "The Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatographic Analysis," May 1988.

[3] The **boldface** numbers in parentheses refer to the list of references at the end of the standard.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[5] Available from the U.S. Dept. of Commerce, National Technical Information Service, Port Royal Road, Springfield, VA 22161 or http://www.epa.gov/ttn/amtic/airtox.html.

TABLE 1 Typical Volatile Organic Compounds Determined by the Canister Method

Compound (Synonym)	Formula	Molecular Weight	Boiling Point (°C)	Melting Point (°C)	CAS Number
Freon 12 (Dichlorodifluoromethane)	Cl_2CF_2	120.91	−29.8	−158.0	
Methyl chloride (Chloromethane)	CH_3Cl	50.49	−24.2	−97.1	74-87-3
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	$ClCF_2CClF_2$	170.93	4.1	−94.0	
Vinyl chloride (Chloroethylene)	$CH_2{=}CHCl$	62.50	−13.4	−1538.0	75-01-4
Methyl bromide (Bromomethane)	CH_3Br	94.94	3.6	−93.6	74-83-9
Ethyl chloride (Chloroethane)	CH_3CH_2Cl	64.52	12.3	−136.4	75-00-3
Freon 11 (Trichlorofluoromethane)	CCl_3F	137.38	23.7	−111.0	
Vinylidene chloride (1,1-Dichloroethene)	$C_2H_2Cl_2$	96.95	31.7	−122.5	75-35-4
Dichloromethane (Methylene chloride)	CH_2Cl_2	84.94	39.8	−95.1	75-09-2
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	CF_2ClCCl_2F	187.38	47.7	−36.4	
1,1-Dichloroethane	CH_3CHCl_2	98.96	57.3	−97.0	74-34-3
cis-1,2-Dichloroethylene	$CHCl{=}CHCl$	96.94	60.3	−80.5	
Chloroform (Trichloromethane)	$CHCl_3$	119.38	61.7	−63.5	67-66-3
1,2-Dichloroethane (Ethylene dichloride)	$ClCH_2CH_2Cl$	98.96	83.5	−35.3	107-06-2
Methyl chloroform (1,1,1,-Trichloroethane)	CH_3CCl_3	133.41	74.1	−30.4	71-55-6
Benzene	C_6H_6	78.12	80.1	5.5	71-43-2
Carbon tetrachloride (Tetrachloromethane)	CCl_4	153.82	76.5	−23.0	56-23-5
1,2-Dichloropropane (Propylene dichloride)	$CH_3CHClCH_2Cl$	112.99	96.4	−100.4	78-87-5
Trichloroethylene (Trichloroethene)	$ClCH{=}CCl_2$	131.29	87	−73.0	79-01-6
cis-1,3-Dichloropropene (cis-1,3-dichloropropylene)	$CH_3CC{=}CHCl$	110.97	76		
trans-1,3-Dichloropropene (trans-1,3-Dichloropropylene)	$ClCH_2CH{=}CHCl$	110.97	112.0		
1,1,2-Trichloroethane (Vinyl trichloride)	$CH_2ClCHCl_2$	133.41	113.8	−36.5	79-00-5
Toluene (Methyl benzene)	$C_6H_5CH_3$	92.15	110.6	−95.0	108-88-3
1,2-Dibromoethane (Ethylene dibromide)	$BrCH_2CH_2Br$	187.88	131.3	9.8	106-93-4
Tetrachloroethylene (Perchloroethylene)	$Cl_2C{=}CCl_2$	165.83	121.1	−19.0	127-18-4
Chlorobenzene	C_6H_5Cl	112.56	132.0	−45.6	108-90-7
Ethylbenzene	$C_6H_5C_2H_5$	106.17	136.2	−95.0	100-41-4
m-Xylene (1,3-Dimethylbenzene)	$1,3\text{-}(CH_3)_2C_6H_4$	106.17	139.1	−47.9	
p-Xylene (1,4-Dimethylxylene)	$1,4\text{-}(CH_3)_2C_6H_4$	106.17	138.3	13.3	
Styrene (Vinyl benzene)	$C_6H_5CH{=}CH_2$	104.16	145.2	−30.6	100-42-5
1,1,2,2-Tetrachloroethane	$CHCl_2CHCl_2$	167.85	146.2	−36.0	79-34-5
o-Xylene (1,2-Dimethylbenzene)	$1,2\text{-}(CH_3)_2C_6H_4$	106.17	144.4	−25.2	
1,3,5-Trimethylbenzene (Mesitylene)	$1,3,5\text{-}(CH_3)_3C_6H_6$	120.20	164.7	−44.7	108-67-8
1,2,4-Trimethylbenzene	$1,2,4\text{-}(CH_3)_3C_6H_6$	120.20	169.3	−43.8	95-63-6
m-Dichlorobenzene (1,3-Dichlorobenzene)	$1,3\text{-}Cl_2C_6H_4$	147.01	173.0	−24.7	541-73-1
Benzyl chloride (α-Chlorotoluene)	$C_6H_5CH_2Cl$	126.59	179.3	−39.0	100-44-7
o-Dichlorobenzene (1,2-Dichlorobenzene)	$1,2\text{-}Cl_2C_6H_4$	147.01	180.5	−17.0	95-50-1
p-Dichlorobenzene (1,4-Dichlorobenzene)	$1,4\text{-}Cl_2C_6H_4$	147.01	174.0	53.1	106-46-7
1,1,2,3,4,4–Hexachloro–1,3-butadiene	Cl_6C_4	260.76	215	-21.0	7-68-3

3.2.1 *absolute canister pressure*—$Pg + Pa$, where Pg = gage pressure in the canister. (kPa, psi) and Pa = barometric pressure.

3.2.2 *absolute pressure*—pressure measured with reference to absolute zero pressure (as opposed to atmospheric pressure), usually expressed as kPa, mm Hg, or psia.

3.2.3 *certification*—the process of demonstrating with humid zero air and humid calibration gases that the sampling systems components and the canister will not change the concentrations of sampled and stored atmospheres.

3.2.4 *cryogen*—a refrigerant used to obtain very low temperatures in the cryogenic trap of the analytical system. A typical cryogen is liquid argon (bp −185.7°C) or liquid nitrogen (bp −195°C).

3.2.5 *dynamic calibration*—calibration of an analytical system using calibration gas standard concentrations generated by diluting known concentration compressed gas standards with purified, humidified inert gas.

3.2.5.1 *Discussion*—Such standards are in a form identical or very similar to the samples to be analyzed. Calibration standards are introduced into the inlet of the sampling or analytical system in the same manner as authentic field samples.

3.2.6 *gage pressure*—pressure measured above ambient atmospheric pressure (as opposed to absolute pressure). Zero gage pressure is equal to ambient atmospheric (barometric) pressure.

3.2.7 *megabore column*—chromatographic column having an internal diameter (I.D.) greater than 0.50 mm.

3.2.7.1 *Discussion*—The Megabore column is a trademark of the J & W Scientific Co. For purposes of this test method, Megabore refers to chromatographic columns with 0.53 mm I.D.

3.2.8 *MS-SCAN*—the GC is coupled to a Mass Spectrometer (MS) programmed to scan all ions over a preset range repeatedly during the GC run.

3.2.8.1 *Discussion*—As used in the current context, this procedure serves as a qualitative identification and characterization of the sample.

3.2.9 *MS-SIM*—the GC is coupled to a MS programmed to acquire data for only specified ions and to disregard all others. This is performed using selected ion monitoring (SIM) coupled to retention time discriminators. The GC-SIM analysis provides quantitative results for selected constituents of the sample gas as programmed by the user.

3.2.10 *pressurized sampling*—collection of an air sample in a canister with a (final) canister pressure above atmospheric pressure, using a sample pump.

3.2.11 *qualitative accuracy*—the ability of an analytical system to correctly identify compounds.

3.2.12 *quantitative accuracy*—the ability of an analytical system to correctly measure the concentration of an identified compound.

3.2.13 *static calibration*—calibration of an analytical system using standards in a form different than the samples to be analyzed.

3.2.13.1 *Discussion*—An example of a static calibration would be injecting a small volume of a high concentration standard directly onto a GC column, bypassing the sample extraction and preconcentration portion of the analytical system.

3.2.14 *subatmospheric sampling*—collection of an air sample in an evacuated canister to a (final) canister pressure below atmospheric pressure, with or without the assistance of a sampling pump.

3.2.14.1 *Discussion*—The canister is filled as the internal canister pressure increases to ambient or near ambient pressure. An auxiliary vacuum pump may be used as part of the sampling system to flush the inlet tubing prior to or during sample collection.

4. Summary of Test Method

4.1 The method described is taken from published work (**1-22**) and is the basis of EPA Compendium Method TO-14A. It has been used since the early 1980s in studies to establish long term trends in certain atmospheric gases (11), to determine the prevalence and extent of VOC contributions to ozone production (12), and to assess the toxicity of VOCs in the ambient air (13,14).

4.2 Both subatmospheric pressure and pressurized sampling modes use an evacuated canister. A sampling line less than 2 % of the volume of the canister or a pump-ventilated sample line are used during sample collection. Pressurized sampling requires an additional pump to provide positive pressure to the sample canister. A sample of air is drawn through a sampling train comprising components that regulate the rate and duration of sampling into a precleaned and pre-evacuated passivated canister.

TABLE 2 Ion/Abundance and Expected Retention Time for Selected VOCs Analyzed by GC-MS-SIM

Compound	Ion/ Abundance (amu/% base peak)	Expected Retention Time (min)
Freon 12 (Dichlorodifluoromethane)	85/100 87/31	5.01
Methyl chloride (Chloromethane)	50/100 52/34	5.69
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	85/100 135/56 87/33	6.55
Vinyl chloride (Chloroethene)	62/100 27/125 64/32	6.71
Methyl bromide (Bromomethane)	94/100 96/85	7.83
Ethyl chloride (Chloroethane)	64/100 29/140 27/140	8.43
Freon 11 (Trichlorofluoromethane)	101/100 103/67	9.97
Vinylidene chloride (1,1-Dichloroethylene)	61/100 96/55 63/31	10.93
Dichloromethane (Methylene chloride)	49/100 84/65 86/45	11.21
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	151/100 101/140 103/90	11.60
1,1-Dichloroethane	63/100 27/64 65/33	12.50
cis-1,2-Dichloroethylene	61/100 96/60 98/44	13.40
Chloroform (Trichloromethane)	83/100 85/65 47/35	13.75
1,2-Dichloroethane (Ethylene dichloride)	62/100 27/70 64/31	14.39
Methyl chloroform (1,1,1-Trichloroethane)	97/100 99/64 61/61	14.62
Benzene	78/100 77/25 50/35	15.04
Carbon tetrachloride (Tetrachloromethane)	117/100 119/97	15.18
1,2-Dichloropropane (Propylene dichloride)	63/100 41/90 62/70	15.83
Trichloroethylene (Trichloroethene)	130/100 132/92 95/87	16.10
cis-1,3-Dichloropropene	75/100 39/70 77/30	16.96
trans-1,3-Dichloropropene	75/100 39/70 77/30	17.49
1,1,2-Trichloroethane (Vinyl trichloride)	97/100 83/90 61/82	17.61
Toluene (Methyl benzene)	91/100 92/57	17.86
1,2-Dibromoethane (Ethylene dibromide)	107/100 109/96 27/115	18.48
Tetrachloroethylene (Perchloroethylene)	166/100 164/74 131/60	19.01
Chlorobenzene	112/100 77/62 114/32	19.73
Ethylbenzene	91/100 106/28	20.20
m,p-Xylene (1,3/1,4-dimethylbenzene)	91/100 106/40	20.41
Styrene (Vinyl benzene)	104/100 78/60 103/49	20.81
1,1,2,2-Tetrachloroethane	83/100 85/64	20.92

TABLE 2 *Continued*

Compound	Ion/ Abundance (amu/% base peak)	Expected Retention Time (min)
o-Xylene (1,2-Dimethylbenzene)	91/100 106/40	20.92
4-Ethyltoluene	105/100 120/29	22.53
1,3,5-Trimethylbenzene (Mesitylene)	105/100 120/42	22.65
1,2,4-Trimethylbenzene	105/100 120/42	23.18
m-Dichlorobenzene (1,3-Dichlorobenzene)	146/100 148/65 111/40	23.31
Benzyl chloride (α-Chlorotoluene)	91/100 126/26	23.32
p-Dichlorobenzene (1,4-Dichlorobenzene)	146/100 148/65 111/40	23.41
o-Dichlorobenzene (1,2-Dichlorobenzene)	146/100 148/65 111/40	23.88
1,2,4-Trichlorobenzene	180/100 182/98 184/30	26.71
Hexachlorobutadiene (1,1,2,3,4,4-Hexachloro-1,3-butadiene)	225/100 227/66 223/60	27.68

4.3 After the air sample is collected, the canister isolation valve is closed, the canister is removed from the sampler, an identification tag is attached to the canister, and the canister is transported to a laboratory for analysis.

4.4 Upon receipt at the laboratory, the data on the canister tag are recorded and the canister is attached to a pressure gage which will allow accurate measurement of the final canister pressure. During analysis, water vapor may be reduced in the gas stream by a permeable membrane dryer (if applicable), and the VOCs are then concentrated by collection on a sorbent trap or in a cryogenically-cooled trap. The temperature of the trap is raised and the VOCs originally collected in the trap are revolatilized, separated on a GC column, and then detected by a mass spectrometer. Compound identification and quantitation are performed with this test method.

4.5 The VOCs are thermally desorbed from the trap into a small volume of carrier gas, separated by gas chromatography, and measured by a mass spectrometric detector or other detector(s) such as the flame ionization detector (FID) or electron capture detector (ECD). The analytical procedure can be automated (15-17) or manual (18). A procedure for measuring total FID response to a sample without gas chromatographic separation is also documented (19).

4.6 A mass spectrometric detector (MS coupled to a GC) is the principal analytical tool used for qualitative and quantitative analysis because it allows positive compound identification. MS detectors include, but are not limited to, magnetic sector mass analyzers, quadrupole mass filters, combined magnetic sector-electrostatic sector mass analyzers, time-of-flight mass analyzers and ion trap mass spectrometers.

4.6.1 *Comparison of GC/MS–Full Scan and GC/MS-SIM*:

4.6.1.1 *GC/MS–Full Scan*:

(1) Positive nontarget compound identification possible,

(2) Less sensitivity than GC/MS-SIM,

(3) Greater sample volume may be required compared to SIM,

(4) Resolution of co-eluting interfering ions is possible,

(5) Positive compound identification,

(6) Quantitative determination of compounds on calibration list, and

(7) Qualitative and semiquantitative determination of compounds not contained on calibration list.

4.6.1.2 *GC/MS-SIM*:

(1) Can't identify non-target compounds,

(2) Less operator interpretation, and

(3) Higher sensitivity than GC/MS–full scan.

4.6.2 The GC/MS–full scan option uses a capillary column GC coupled to a MS operated in a scanning mode and supported by spectral library search routines. This option offers the nearest approximation to unambiguous identification and covers a wide range of compounds as defined by the completeness of the spectral library. GC/MS-SIM mode is limited to a set of target compounds which are user defined and is more sensitive than GC/MS-SCAN by virtue of the longer dwell times at the restricted number of m/z values. As the number of ions monitored simultaneously in a GC/MS-SIM analysis increases, the sensitivity of this technique approaches GC/MS-SCAN. The practical limit for GC/MS-SIM is reached at about 4 to 5 ions monitored simultaneously.

5. Significance and Use

5.1 VOCs are emitted into the ambient, indoor, and workplace atmosphere from a variety of sources. In addition to the emissions from the use of various products, appliances, and building materials, fugitive or direct emissions from ambient sources such as manufacturing processes further complicate air composition. Many of these VOC compounds are acute or chronic toxins. Therefore, their determination in air is necessary to assess human health impacts.

5.2 The use of canisters is particularly well suited for the collection and analysis of very volatile, stable compounds in atmosphere (for example, vinyl chloride). This test method collects and analyzes whole gas samples and is not subject to high volatility limitations.

5.3 VOCs can be successfully collected in passivated stainless steel canisters. Collection of atmospheric samples in canisters provides for: *(1)* convenient integration of air samples over a specific time period (for example, 8 to 24 h), *(2)* remote sampling and central laboratory analysis, *(3)* ease of storing and shipping samples, *(4)* unattended sample collection, *(5)* analysis of samples from multiple sites with one analytical system, *(6)* dilution or additional sample concentration to keep the sample size introduced into the analytical instrument within the calibration range, *(7)* collection of sufficient sample volume to allow assessment of measurement precision or analysis, or both, of samples by several analytical systems, and *(8)* sample collection in remote access areas using a vacuum regulator flow controller if electricity is not available.

5.4 Interior surfaces of the canisters are treated by any of several proprietary passivation processes including an electropolishing process to remove or cover reactive metal sites on the interior surface of the vessel and a fused silica coating process.

5.5 This test method can be applied to sampling and analysis of compounds that can be quantitatively recovered from the canisters. The typical range of VOC applicable to this test method are ones having saturated vapor pressures at 25°C greater than 15 Pa (10^{-1} mm Hg).

5.6 Recovery and stability studies must be conducted on any compound not listed in Table 1 before expanding the use of this test method to additional compounds.

6. Interferences and Limitations

6.1 Water management is a significant analytical problem because VOC preconcentrators typically accumulate water vapor as well as VOCs, especially those preconcentrators that use reduced temperature condensation. The water can restrict and even stop the sample air flow, alter retention times, and affect the operation of detector systems, especially the mass spectrometric systems. In-line permeable membrane dryers are frequently used prior to preconcentration and do not produce artifacts for a number of compounds including those that are on the target list for this method provided certain precautions are observed **(20,21)**. Release of an air sample from a pressurized canister that contains humid air will result in a systematic increase in the humidity of the released sample air as long as condensed water remains on the canister interior **(22)**.

6.2 For those applications where a membrane dryer is used, interferences can occur in sample analysis if moisture accumulates in the dryer (see 10.1.1.3). An automated cleanup procedure that periodically heats the dryer to about 100°C while purging with zero air eliminates any moisture buildup. This procedure does not degrade sample integrity.

NOTE 1—Removing moisture from samples is not necessary with GC/MS systems that are differentially pumped and which do not employ membrane drying apparatus.

6.3 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (for example, pump and flow controllers) must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples. Instructions for cleaning the canisters and certifying the field sampling system are described in 11.1 and 11.2, respectively. In addition, sufficient system and field blank samples shall be analyzed to detect contamination as soon as it occurs.

6.4 If the GC/MS analytical system employs a permeable membrane dryer or equivalent to remove water vapor selectively from the sample stream, polar organic compounds will permeate this membrane concurrently with the moisture. Consequently, the analyst must calibrate his or her system with the specific organic constituents under examination. For quantitative analysis of polar compounds analytical systems may not employ permeable membrane dryers.

7. Apparatus

7.1 Stainless steel canisters with interior surfaces passivated by either electropolishing or silica coating, available from various commercial sources.

7.2 Subatmospheric pressure and pressurized canister sampling systems are commercially available and have been evaluated for VOC testing in air **(8-10)**. Several configurations of standard hardware can be used successfully as canister sampling units.

7.2.1 *Subatmospheric Pressure* (see Fig. 1).

7.2.1.1 *Inlet Line*, Stainless steel tubing to connect the sampler to the sample inlet.

7.2.1.2 *Canister*, Leak-free stainless steel pressure vessels of desired volume (for example, 6 L), with valve and passivated interior surfaces.

7.2.1.3 *Vacuum/Pressure Gage,* Capable of measuring vacuum (−100 to 0 kPa or 0 to 30 in Hg) and pressure (0 to 200 kPa or 0 to 30 psig) in the sampling system. Gages shall be tested clean and leak tight.

7.2.1.4 *Mass Flow Meter and Controller,* Capable of maintaining a constant flow rate (±10 %) over a sampling period of up to 24 h and under conditions of changing temperature (20 to 40°C) and humidity.

7.2.1.5 *Filter*, 7-µm sintered stainless-steel in-line filter.

7.2.1.6 *Electronic Timer,* Capable of activating a solenoid valve (see 7.2.1.7) to start and stop flow entering a canister, that is, for unattended sample collection.

7.2.1.7 *Solenoid Valve*, Electrically operated, bi-stable solenoid valve with fluoroelastomer seat and o-rings, or low temperature solenoid valve.

7.2.1.8 *Tubing and Fittings*, Chromatographic grade stainless steel tubing and fittings for interconnections. All such materials in contact with sample, analyte, and support gases prior to analysis shall be chromatographic grade stainless steel.

7.2.1.9 *Heater*, Thermostatically controlled to maintain temperature inside insulated sampler enclosure above ambient temperature if needed.

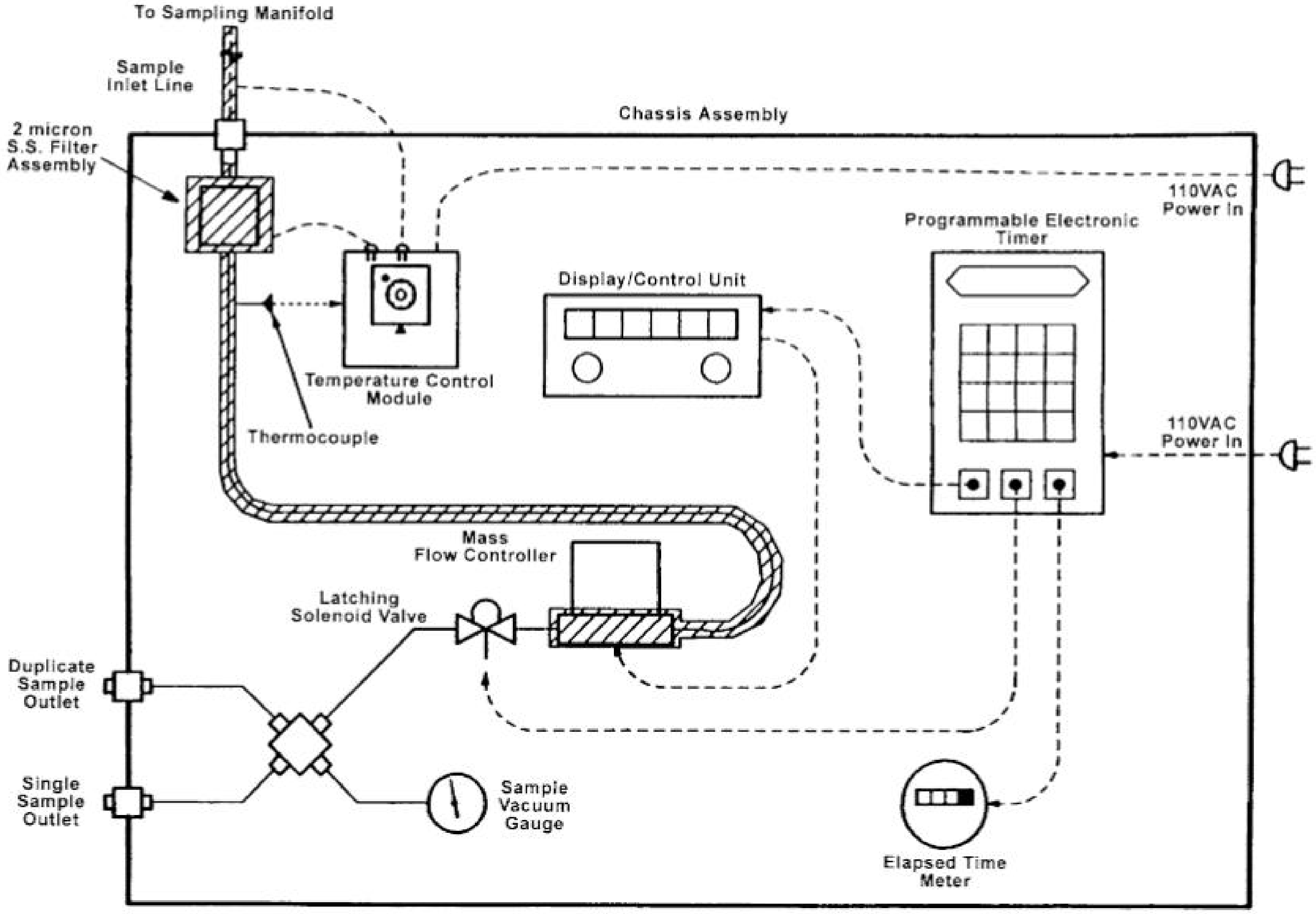
7.2.1.10 *Fan*, For cooling sampling system, if needed.

7.2.1.11 *Thermostat*, Automatically regulates fan operation, if needed.

7.2.1.12 *Maximum-Minimum Thermometer*, Records highest and lowest temperatures during sampling period.

7.2.1.13 *Shut-Off Valve*, Stainless steel—leak free, for vacuum/pressure gage.

7.2.1.14 *Auxiliary Vacuum Pump (optional)*, continuously draws air to be sampled through the inlet manifold at 10 L/min or higher flow rate. Sample is extracted from the manifold at a lower rate, and excess air is exhausted. The use of higher inlet flow rates dilutes any contamination present in the inlet and reduces the possibility of sample contamination as a result of



Note: All fittings 316 stainless steel
Note: All tubing 3.2-mm (1/8") O.D. 304 chromatographic grade stainless steel
Note: ▨ — Temperature controlled area

FIG. 1 Sampler Configuration For Subatmospheric Pressure Canister Sampling

contact with active adsorption sites on inlet walls. Pump is not necessary if the intake manifold represents less than 5 % of the final sample.

7.2.1.15 *Elapsed Time Meter*, Capable of measuring the duration of sampling to the nearest second.

7.2.1.16 *Optional Fixed Orifice, Capillary, Adjustable Micrometering Valve, or Vacuum Regulator*, May be used in lieu of the electronic flow controller for grab samples or short duration time-integrated samples. Such systems require manual activation and deactivation. In this standard, application of a pumpless simple orifice sampler is appropriate only in situations where samples consume 60 % or less of the total capacity of the canister used for collection. Typically this limits the sample duration to a maximum of 8 h per 6 L canister or 20 h per 15 L canister.

7.2.2 *Pressurized*, See Fig. 1 and Fig. 2.

7.2.2.1 *Sample Pump*, Stainless steel pump head, metal bellows type capable of 200 kPa output pressure. Pump must be free of leaks, clean, and uncontaminated by oil or organic compounds.

NOTE 2—Several sampling systems have been developed that result in pressurizing a canister with sample air. The system illustrated in Fig. 2 uses an auxiliary vacuum pump to flush the sample inlet. A non-contaminating air pump pulls air from the inlet tubing, through a critical orifice which regulates the flow, and into the canisters.

7.2.2.2 *Other Supporting Materials*, All other components of the pressurized sampling system are similar to components discussed in 7.2.1.1-7.2.1.16.

7.3 *Sample Analysis Equipment*:

7.3.1 *GC/MS-Analytical System (Full Scan and SIM)*.

7.3.1.1 The GC/MS-SCAN analytical system must be capable of acquiring and processing data in the MS–full scan mode. The GC/MS-SIM analytical system must be capable of acquiring and processing data in the MS-SIM mode.

7.3.1.2 *Gas Chromatograph*, Capable of sub-ambient temperature programming for the oven, with other standard features such as gas flow regulators, automatic control of valves and integrator, etc. Flame ionization detector optional.

7.3.1.3 *Chromatographic Detector*, Mass spectrometric detector equipped with computer and appropriate software. The GC/MS is set in the SCAN mode, where the MS screens the sample for identification and quantitation of VOC species.

7.3.1.4 *Cryogenic Trap with Temperature Control Assembly*, Refer to 10.1.1.4 for complete description of trap and temperature control assembly. Traps may be built into the gas chromatograph by the manufacturer or added to existing units.

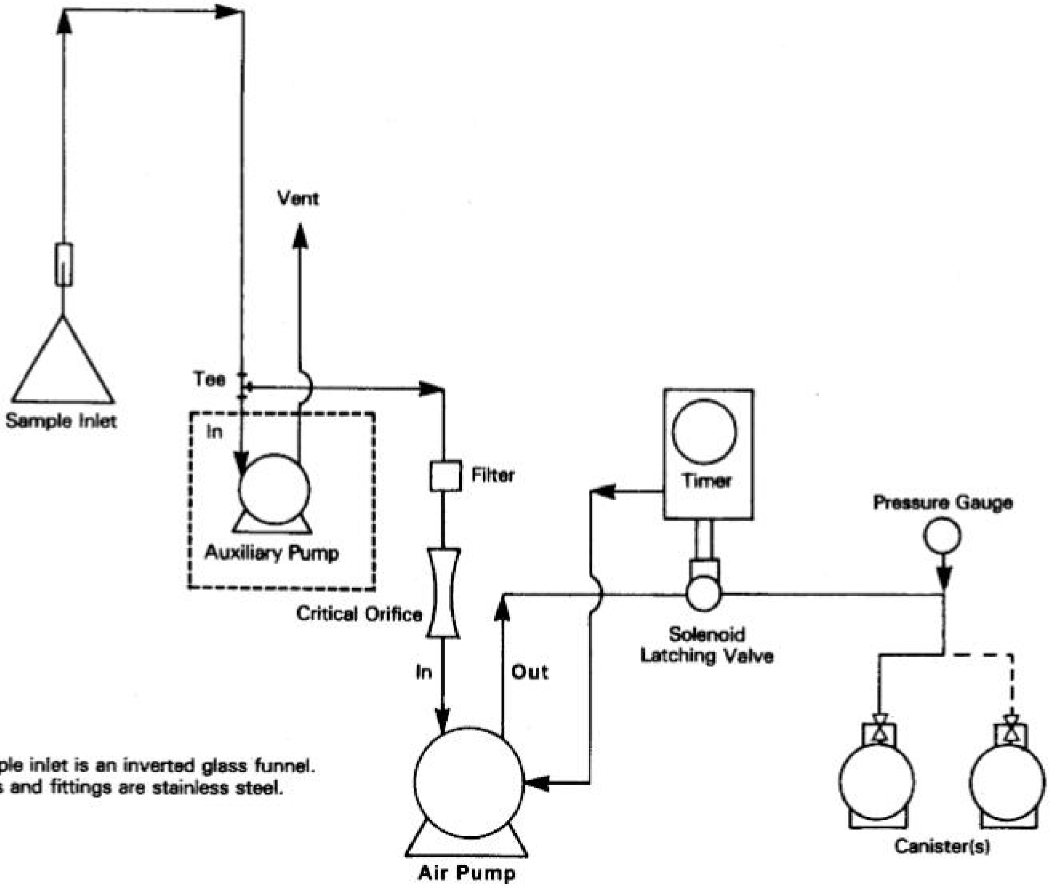


FIG. 2 Alternative Sampler Configuration for Pressurized Canister Sampling

7.3.1.5 *Electronic Mass Flow Controllers (3)*, To maintain constant flow for carrier gas and sample gas and to provide analog output to monitor flow anomalies.

7.3.1.6 *Vacuum Pump*, General purpose laboratory pump, capable of evacuating a known volume reservoir (which will be used for sample transfer) or for drawing the desired sample volume through the cryogenic trap.

7.3.1.7 *Chromatographic Grade Stainless Steel Tubing and Stainless Steel Plumbing Fittings*, Refer to 7.2.1.8 for description.

7.3.1.8 *Chromatographic Column (see Table 3)*, To provide compound separation.

NOTE 3—Other columns (6 % cyanopropylphenyl/94 % dimethylpolysiloxane) can be used as long as the system meets user needs. The wider megabore column (that is, 0.53 mm I.D.) is less susceptible to plugging as a result of trapped water, thus eliminating the need for a permeable membrane dryer in the analytical system. The megabore column has sample capacity approaching that of a packed column, while retaining much of the peak resolution traits of narrower columns (that is, 0.32 mm I.D.).

7.3.1.9 *Stainless Steel Vacuum/Pressure Gage (optional)*, Capable of measuring vacuum (−100 to 0 kPa) and pressure (0–200 kPa) in the sampling system. Gages shall be tested clean and leak tight.

7.3.1.10 *Cylinder Pressure Stainless Steel Regulators*, Standard, two-stage cylinder regulators with pressure gages for helium, zero air, nitrogen, and hydrogen gas cylinders.

TABLE 3 General GC and MS Operating Conditions

Chromatography	
Column	50–m × 0.32–mm I.D. crosslinked 100 % dimethylpolysiloxane (17 μm film thickness)
Carrier Gas	Helium (2.0 cm³/min at 250°C)
Injection Volume	Constant (1–3 μL)
Injection Mode	Splitless
Temperature Program	
Initial Column Temperature	−50°C
Initial Hold Time	2 min
Program	8°C/min to 150°C
Final Hold Time	15 min
Mass Spectrometer	
Mass Range	18 to 250 amu
Scan Time	1 s/scan
EI Condition	70 eV
Mass Scan	Follow manufacturer's instruction for selecting mass selective detector (MS) and selected ion monitoring (SIM) mode
Detector Mode	Multiple ion detection
FID System (Optional)	
Hydrogen Flow	30 cm³/min
Carrier Flow	30 cm³/min
Burner Air	400 cm³/min

7.3.1.11 *Gas Purifiers (4)*, Molecular sieve or carbon used to remove organic impurities and moisture from gas streams.

7.3.1.12 *Low Dead-Volume Tee or Press Fit Splitter (optional)*, Used to split the exit flow from the GC column.

7.3.1.13 *Dryer (optional)*, Consisting of permeable membrane tubing coaxially mounted within larger tubing, available commercially. Refer to 10.1.1.3 for description.

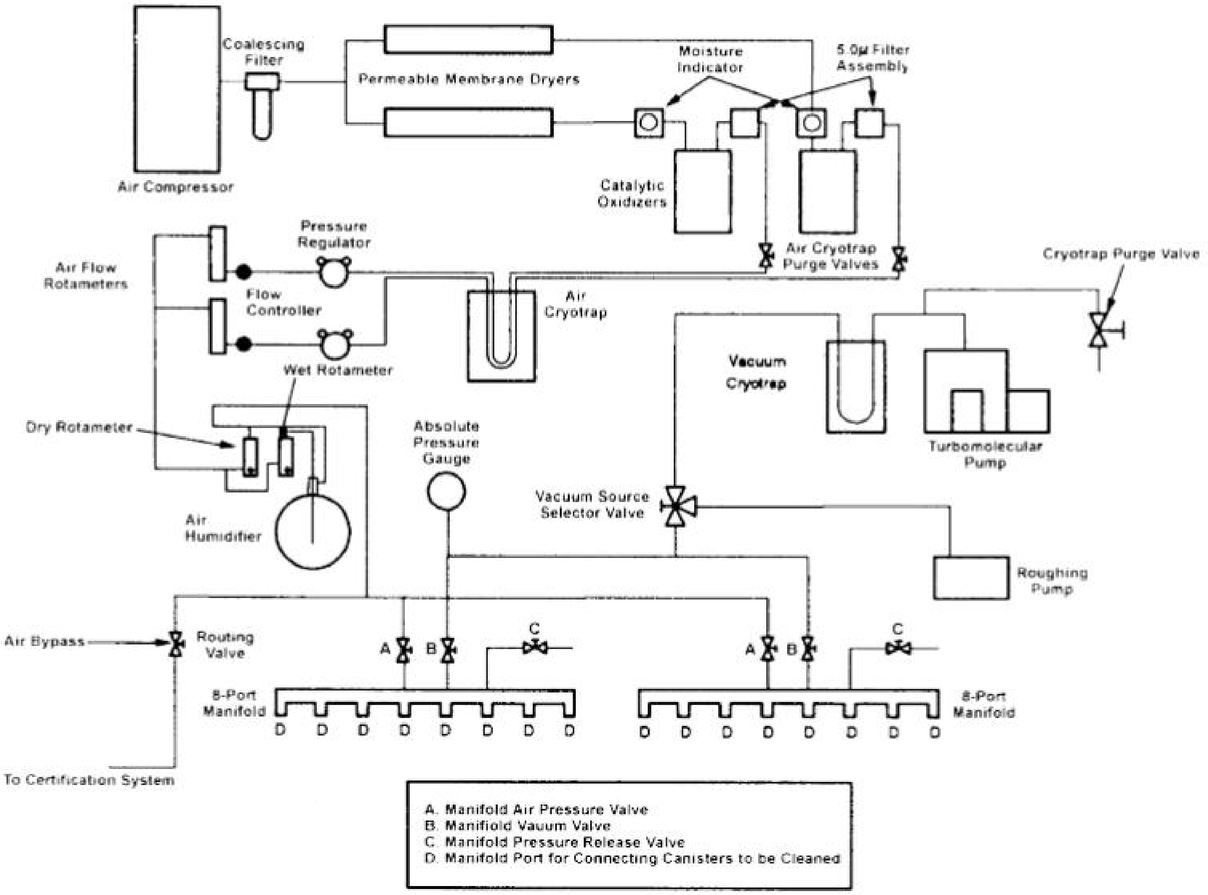


FIG. 3 Canister Cleanup Apparatus

7.3.1.14 *Six-Port Gas Chromatographic Valve.*

7.4 *Canister Cleaning System (see Fig. 3)*:

7.4.1 *Vacuum Pump*, Capable of evacuating sample canister(s) to an absolute pressure of less than 0.0064 kPa (0.05 mm Hg).

7.4.2 *Manifold*, Made of stainless steel with connections for simultaneously cleaning several canisters.

7.4.3 *Shut-Off Valve(s)*, On-off toggle valves.

7.4.4 *Stainless Steel Vacuum Gage*, Capable of measuring vacuum in the manifold to an absolute pressure of 0.0064 kPa (0.05 mm Hg) or less.

7.4.5 *Cryogenic Trap (2 required)*, Made of stainless steel U-shaped open tubular trap cooled with liquid nitrogen, for air purification purposes to prevent contamination from back diffusion of oil from vacuum pump and to provide clean, zero air to sample canister(s).

7.4.6 *Stainless Steel Pressure Gages (2)*, 0 to 350 kPa (0 to 50 psig) to monitor zero air pressure.

7.4.7 *Stainless Steel Flow Control Valve*, To regulate flow of zero air into canister(s).

7.4.8 *Humidifier*, Consisting of Pressurizable Water Bubbler, (typically a passivated canister equipped with dip tube and dual valves). Humidifier contains high performance liquid chromatography (HPLC) grade deionized water.

7.4.9 *Isothermal Oven (optional)*, For heating canisters.

NOTE 4—Oven temperature must not exceed the manufacturer's recommendation during cleaning to avoid degradation of the passivated canister surface on repeated cleaning.

7.5 *Calibration System and Manifold (see Fig. 4)*:

7.5.1 *Calibration Manifold*, Chromatographic grade stainless steel or glass manifold (125 mm I.D. by 660 mm), with sampling ports and internal mixing for flow disturbance to ensure proper mixing.

7.5.2 *Humidifier*, 500-mL impinger flask containing HPLC grade deionized water.

7.5.3 *Electronic Mass Flow Controllers*, One 0 to 5 L/min and one 0 to 50 mL/min.

7.5.4 *TFE–Fluorocarbon Filter(s)*, 47–mm TFE–Fluorocarbon filter for particulate control.

8. Reagents and Materials

8.1 Gas cylinders of helium, hydrogen, nitrogen, and zero air ultrahigh purity grade.

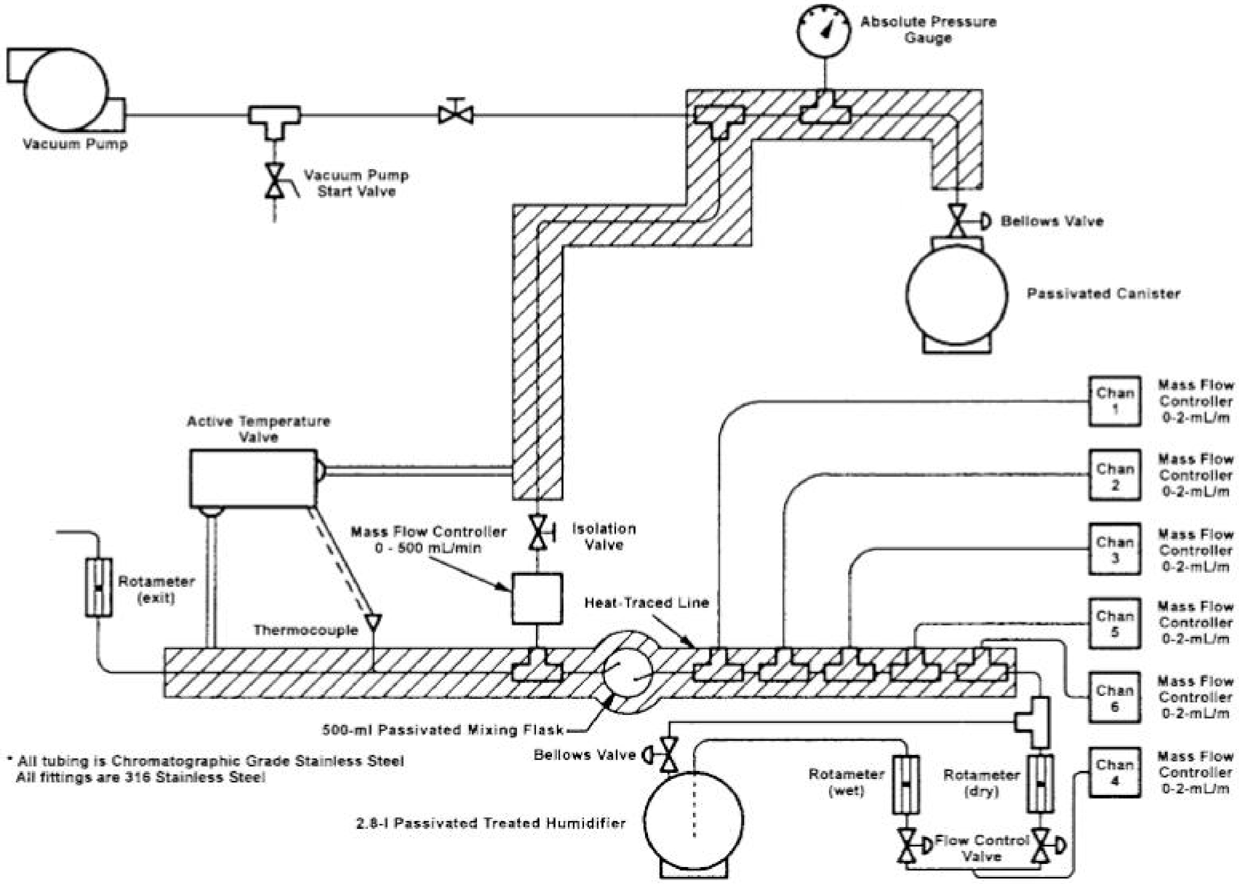


FIG. 4 Schematic of Calibration System and Manifold for (a) Analytical System Calibration, (b) Testing Canister Sampling System and (c) Preparing Canister Transfer Standards

8.2 Gas calibration standards—cylinder(s) containing approximately 10 ppmv of each of the following compounds of interest:

vinyl chloride
vinylidene chloride
1,1,2-trichloro-1,2,2-trifluoroethane
p-dichlorobenzene
chloroform
1,2-dichloroethane
benzene
toluene
dichlorodifluoromethane
methyl chloride
ethylbenzene
1,2,4-trichlorobenzene
methyl bromide
ethyl chloride
fluorotrichloromethane
dichloromethane
1,1-dichloroethane
cis-1,2-dichloroethylene
1,2-dichloropropane
1,1,2-trichloroethane
1,2-dibromoethane
tetrachloroethylene
chlorobenzene
benzyl chloride
hexachloro-1,3-butadiene
methyl chloroform
carbon tetrachloride
trichloroethylene
cis-1,3-dichloropropene
trans-1,3-dichloropropene
1,2-dichloro-1,1,2,2-tetrafluoroethane
o-dichlorobenzene
o-xylene
m-xylene
p-xylene
styrene
1,1,2,2-tetrachloroethane
1,3,5-trimethylbenzene
1,2,4-trimethylbenzene
m-dichlorobenzene

8.2.1 The cylinder(s) shall be traceable to a National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) or to a NIST/EPA approved Certified Reference Material (CRM). The components may be purchased in one cylinder or may be separated into different cylinders. Refer to manufacturer's specification for guidance on purchasing and mixing VOCs in gas cylinders. Those compounds purchased should match one's own target list.

8.3 *Liquid Nitrogen (bp −195.8°C)*, used only for clean air traps and GC oven coolant, and sample concentration traps requiring active control to maintain −185.7°C.

8.4 *Liquid Argon (bp −185.7°C)*, for sample traps that are not actively controlled to −185.7°C.

8.5 *Gas Purifiers*—Molecular sieve or carbon, connected in-line between hydrogen, nitrogen, and zero air gas cylinders and system inlet line, to remove moisture and organic impurities from gas streams.

8.6 *Deionized Water*—High performance liquid chromatography (HPLC) grade, ultrahigh purity (for humidifier).

8.7 *4-Bromofluorobenzene*—Used for tuning GC/MS.

8.8 *Methanol*—For cleaning sampling system components, reagent grade.

9. Sampling System

9.1 *System Description*:

9.1.1 *Subatmospheric Pressure Sampling*—See Fig. 1 or Fig. 2.

9.1.1.1 In preparation for subatmospheric sample collection in a canister, the canister is evacuated to 0.0064 kPa (0.05 mm Hg) or less. When opened to the atmosphere containing the VOCs to be sampled, the differential pressure causes the sample to flow into the canister. This technique may be used to collect grab samples (duration of 10 to 30 s) or time-integrated samples (duration of 12 to 24 h) taken through a flow-restrictive inlet (for example, mass flow controller, vacuum regulator, or critical orifice).

9.1.1.2 With a critical orifice flow restrictor, there will be a decrease in the flow rate if the pressure approaches atmospheric. However, with a mass flow controller the subatmospheric sampling system can be increased since the restrictor size can be adjusted. For example, an electronic flow controller with a flow rate range of 0 to 50 cc/min can maintain a constant (less than 5 % change) flow rate of 5 cc/min from full vacuum to within 7 kPa (1.0 psi) below ambient pressure.

9.1.2 *Pressurized Sampling*—See Fig. 1.

9.1.2.1 Pressurized sampling is used when longer-term integrated samples or higher volume samples are required. The sample is collected in a canister using a pump and flow control arrangement to achieve a typical 100–200 kPa (15–30 psig) final canister pressure. For example, a 6-L evacuated canister can be filled at 7.1 mL/min for 24 h to achieve a final pressure of about 67 kPa (10.5 psig).

NOTE 5—Collection of pressurized samples in humid environments may result in condensation of water in sampling canisters. The presence of condensed water may decrease the recovery of polar compounds from the canister and change the retention times of target compounds on the GC column.

9.1.2.2 In pressurized canister sampling, a metal bellows type pump draws in air from the sampling manifold to fill and pressurize the sample canister.

9.1.3 *All Samplers*:

9.1.3.1 A flow control device is chosen to maintain a constant flow into the canister over the desired sample period. This flow rate is determined so the canister is filled (to about 88.1 kPa for subatmospheric pressure sampling or to about one atmosphere above ambient pressure for pressurized sampling) over the desired sample period. The flow rate can be calculated by:

$$F = (P \times V)/(t \times 60) \quad (1)$$

where:

F = flow rate, mL/min,
P = final canister pressure, atmospheres absolute. P is approximately equal to [(kPa gage)/100] + 1,
V = volume of the canister, mL, and
t = sample period, h.

9.1.3.2 For example, if a 6–L canister is to be filled to 200 kPa (2 atmospheres) absolute pressure in 24 h, the flow rate can be calculated by:

$$F = (2 \times 6000)/(24 \times 60) = 8.3 \text{ mL/min} \quad (2)$$

9.1.3.3 For automatic operation, the timer is wired to start and stop the pump at appropriate times for the desired sample period. The timer must also control the solenoid valve, to open the valve when starting the pump and close the valve when stopping the pump.

9.1.3.4 The use of a latching solenoid, or low temperature valve, avoids any substantial temperature rise occurring with a conventional, normally energized solenoid during the entire sample period. The temperature rise in the valve could cause outgassing of organic compounds from the valve seat material which must be avoided to reduce background. The latch solenoid valve requires an electronic timer that can be programmed for short (5 to 60 s) "on" periods. Simple electrical pulse circuits for operating latching valves with a conventional mechanical timer are illustrated in Fig. 5.

9.1.3.5 The connecting lines between the sample inlet and the canister shall be as short as possible to minimize their volume. The flow rate into the canister shall remain relatively constant over the entire sampling period (see 9.1.1.2).

9.1.3.6 As an option, a second electronic timer (see 7.2.1.6) may be used to start the auxiliary pump several hours prior to the sampling period to flush and condition the inlet line.

9.1.3.7 Prior to use, each sampling system must pass a humid zero air certification (see 11.2). All plumbing shall be checked carefully for leaks. The canisters must also pass a humid zero air certification before use (see 11.1).

9.2 *Sampling Procedure*:

9.2.1 The sample canister shall be cleaned and tested according to the procedure in 11.1.

9.2.2 A sample collection system is assembled as shown in Fig. 1 (and Fig. 2) and must meet certification requirements as outlined in 11.2.3.

NOTE 6—The sampling system shall be contained in an appropriate enclosure when ambient samples are collected.

9.2.3 Prior to locating the sampling system, the user may want to perform "screening analyses" by taking quick grab samples over a short period of time. The information gathered from the screening samples is used to determine the potential concentration range for analysis and identify potential interferents with the GC/MS analysis. Screening samples should be analyzed using the procedure in this standard. Sampling is performed using a simple sampler described in 7.2.1.16.

9.2.4 Immediately prior to any sample collection record the ambient temperature, humidity, and pressure where the sampler is located.

NOTE 7—The following discussion is related to Fig. 1.

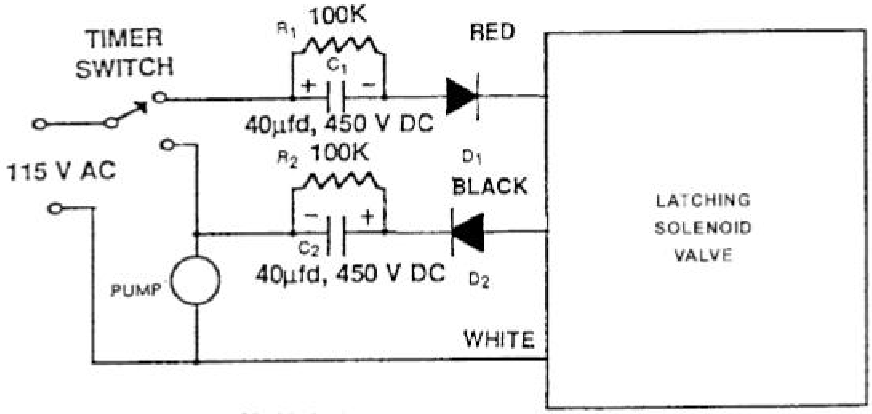
9.2.5 To verify correct sample flow, a "practice" (evacuated) canister is used in the sampling system. Attach a certified mass flow meter to the inlet line of the manifold, just in front of the filter. Open the canister. Start the sampler and compare the reading of the certified mass flow meter to the sampler mass flow controller. The values shall agree within ±10 %. If not, the sampler mass flow meter shall be recalibrated or the sampler must be repaired if a leak is found in the system.

NOTE 8—For a subatmospheric sampler, the flow meter and practice canister are needed. For the pump-driven system, the practice canister is not needed if the flow can be measured as supplied to the canister.

NOTE 9—Mass flow meter readings may drift. Check the zero reading carefully and add or subtract the zero reading when reading or adjusting the sampler flow rate, to compensate for any zero drift. Adjust the desired canister flow rate to the proper value after a 2 min warm up period, using the sampler flow control unit controller (for example, 3.5 mL/min for 24 h, 7.0 mL/min for 12 h). Measure and record the actual final flow.

9.2.6 Turn the sampler off and reset the elapsed time meter to 000.0.

NOTE 10—Any time the sampler is turned off, wait at least 30 s to turn the sampler back on.

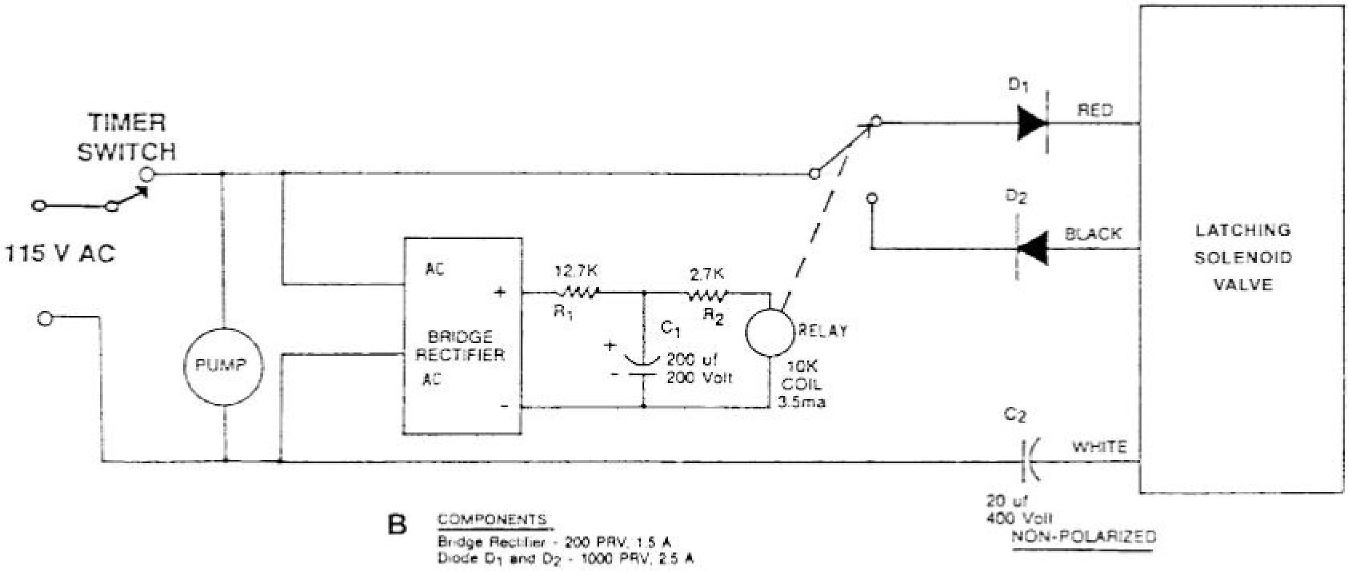


A COMPONENTS

Capacitor C_1 and C_2 - 40 uf, 450 VDC

Resister R_1 and R_2 - 0.5 watt, 5% tolerance

Diode D_1 and D_2 - 1000 PRV, 2.5 A



B COMPONENTS

Bridge Rectifier - 200 PRV, 1.5 A

Diode D_1 and D_2 - 1000 PRV, 2.5 A

Capacitor C_1 - 200 uf, 250 VDC

Capacitor C_2 - 20 uf, 400 VDC Non-Polarized

Relay - 10,000 ohm coil, 3.5 ma

Resister R_1 and R_2 - 0.5 watt, 5% tolerance

FIG. 5 Electrical Pulse Circuits for Driving a Latching Solenoid Valve with a Mechanical Timer

9.2.7 Disconnect the "practice" canister and certified mass flow meter. Attach a clean certified (see 11.1) canister to the system.

9.2.8 Open the canister valve and vacuum/pressure gage valve.

9.2.9 Record the pressure/vacuum in the canister as indicated by the sampler vacuum/pressure gage.

9.2.10 Close the vacuum/pressure gage valve and reset the maximum/minimum thermometer to current temperature. Record time of day and elapsed time meter readings.

9.2.11 Set the electronic timer to begin and stop the sampling period at the appropriate times. Sampling commences and stops by the programmed electronic timer.

9.2.12 After the desired sampling period, record the maximum, minimum, current interior temperature and current ambient or indoor temperature. Record the current reading from the flow controller, the ambient or indoor humidity and pressure.

9.2.13 At the end of the sampling period, briefly open and close the vacuum/pressure gage valve on the sampler and record pressure/vacuum in the canister.

NOTE 11—For a subatmospheric sampling system, if the canister is at atmospheric pressure when the final pressure check is performed, the sampling period may be suspect. This information shall be noted on the sampling field data sheet. Time of day and elapsed time meter readings are also recorded.

9.2.14 Close the canister valve. Disconnect the sampling line from the canister and remove the canister from the sampling system. For a subatmospheric system, connect a certified mass flow meter to the inlet manifold in front of the in-line filter and attach a "practice" canister to the valve of the sampling system. Record the final flow rate.

NOTE 12—Attaching a mass flow meter and recording the flow rate is not necessary if the initial and final canister vacuum are recorded.

NOTE 13—For a pressurized system, the final flow may be measured directly before the sampler is turned off.

9.2.15 Attach an identification tag to the canister. Record canister serial number, sample number, location, and date on the tag.

10. Analytical System

10.1 *System Description*:

10.1.1 *GC/MS System (Full Scan and SIM)*:

10.1.1.1 The analytical system is comprised of a GC equipped with a mass-spectrometric detector set to operate to detect all mass to charge ratios in the analytical range (full scan mode) or to detect a limited number of ions in each of several segments of any analytical run, referred to as the selected ion monitoring or SIM mode. Different types of mass spectrometric systems have different designations for selected ion monitoring. The GC/MS is set up for automatic, repetitive analysis. The GC system is comprised of a GC equipped with a crosslinked 100 % dimethylpolysiloxane-phase capillary column (0.32 mm by 50 m), or equivalent. The system also includes a computer and appropriate software for data acquisition, data reduction, and data reporting. In operation, an air sample (usually 250 to 800 mL) is recovered from the canister and routed to the analytical system. The sample air may be passed through a permeable membrane dryer; however, many polar compounds are not identified using this drying procedure. Sample is routed through a chromatographic valve, then into a cryogenic trap. Concentration of compounds based upon a previously installed calibration table is reported by an automated data reduction program. In full scan mode the GC/MS acquires mass spectral data by continuously scanning a range of masses typically between 18 and 250 amu. A SIM system is programmed to acquire data for only the target compounds and to disregard all others. The sensitivity is typically 1 ppbv or better for a 500 mL air sample.

10.1.1.2 SIM analysis is based on a combination of retention times and relative abundances of selected ions (see Table 2). These qualifiers are stored on the hard disk of the GC/MS computer and are compared to sample data for identification of each chromatographic peak. The retention time qualifier is determined to be, for example ±0.10 min of the library retention time of the compound. The acceptance level for relative abundance is determined to be, for example ±15 % of the expected abundance, except for vinyl chloride and methylene chloride, which is determined to be, for example ±25 %. Three ions are measured for most of the forty compounds. When compound identification is made by the computer, any peak that fails any of the qualifying tests is flagged (for example, with an asterisk). All the data shall be manually examined by the analyst to determine the reason for the flag and whether the compound can be reported as found. While this adds some subjective judgment to the analysis, computer-generated identification problems must be clarified by an experienced operator. Manual inspection of the quantitative results must also be performed to verify concentrations outside the expected range. To realize the maximum sensitivity of SIM, retention time windows shall be chosen for each compound or group of compounds so that the number of ions monitored during a scan is kept to three or four.

10.1.1.3 A permeable membrane dryer may be used to remove water vapor selectively from the sample stream. The permeable membrane consists of tubing made of a copolymer of tetrafluoroethylene and fluorosulfonyl monomer that is coaxially mounted within larger tubing. The sample stream is passed through the interior of the permeable membrane tubing, allowing water (and other light, polar compounds) to permeate through the walls into a dry air purge stream flowing through the annular space between the semipermeable membrane and outer tubing. To prevent excessive moisture build-up and any memory effects in the dryer, a cleanup procedure involving periodic heating of the dryer (100°C for 20 min) while purging with dry zero air (500 mL/min) shall be implemented as part of the user's standard operating procedure (SOP) manual. The clean-up procedure is repeated during each analysis. However, care must be taken when heating the dryer (**21**). Another method for drying the air sample involves freezeout of water in a pre-trap followed by raising the temperature and purging target compounds that move into the gas phase to a downstream trap while leaving most of the water behind. Removal of water with a permeable membrane-type dryer shall not be performed for compounds other than those on the list in Table 1 unless recovery studies are performed to validate analysis of these compounds. Polar compounds are particularly susceptible to loss through the permeable membrane interface.

NOTE 14—A cleanup procedure is particularly useful when employing cryogenic preconcentration of VOCs with subsequent GC analysis because excess accumulated water can cause trap and column blockage and also adversely affect detector precision. This is a particular problem using GC/MSD systems. In addition, the improvement in water removal from the sampling stream will allow analyses of much larger volumes of sample air in the event that greater system sensitivity is required for targeted compounds.

NOTE 15—While a differentially pumped GC/MS analytical system does not need a permeable membrane dryer for drying the sample gas stream, such a dryer may be used with GC/Mass Selective Detector (GC/MSD) type GC/MS systems because GC/MSD units are far more sensitive to excessive moisture than the GC/MS analytical systems. Moisture can adversely affect detector precision.

10.1.1.4 The cryogenic sample trap is heated to at least 120°C and no more than 200°C in approximately 60 s and the analyte is injected onto the capillary column. Rapid heating of the trap provides efficient transfer of the sample components onto the gas chromatographic column. Upon sample injection onto the column, the MS computer is signaled by the GC computer to begin detection of compounds which elute from the column. The gas stream from the GC is scanned within a preselected range of atomic mass units (amu). For detection of compounds in Table 1, the range shall be 18 to 250 amu, resulting in a 1.5 Hz repetition rate. Six scans per eluting chromatographic peak are provided at this rate. Automated computer peak selection, or manual selection of each target compound is performed according to the instrument manufacturer's specifications. A library search is then performed and up to ten of the best matches for each peak are listed. A qualitative characterization of the sample is provided by this procedure.

10.1.1.5 Packed metal tubing is used for reduced temperature trapping of VOCs. The cooling unit is comprised of a 32 mm outside diameter (O.D.) nickel tubing loop packed with 60–80 mesh borosilicate glass beads.

NOTE 16—The nickel tubing loop can be placed in an aluminum or brass block containing a tube heater (500 to 1000 watt) or wound onto a cylindrically formed tube heater (250 watt). A cartridge heater (25 watt) is required for the cylindrically wound trap. This low watt heater is sandwiched between pieces of metal plate at the trap inlet and outlet to provide additional heat to eliminate cold spots in the transfer tubing. Rapid heating (−178 to +120°C in 55 s) is accomplished by direct thermal contact between the heater and the trap tubing. Cooling of aluminum or brass mounted traps is achieved by immersion in liquid cryogen. Cooling of cylindrically wound traps is achieved by vaporization around or submersion of the trap in the cryogen. In the shell, efficient cooling (+120 to −178°C in 225 s) is facilitated by confining the vaporized cryogen to the small open volume surrounding the trap assembly. The trap assembly and chromatographic valve are mounted on a baseplate fitted into the injection and auxiliary zones of the GC on an insulated pad directly above the column oven when used with the Hewlett-Packard 5880 GC.

10.1.1.6 As an option, the analyst may wish to split the gas stream exiting the column with a low dead-volume tee, passing one-third of the sample gas (1.0 mL/min) to the mass selective detector and the remaining two-thirds (2.0 mL/min) through a flame ionization detector. The use of the specific detector (MS-SCAN) coupled with the nonspecific detector (FID) enables enhancement of data acquired from a single analysis. In particular, the FID provides the user with the following:

(1) Semi-real time picture of the progress of the analytical scheme,

(2) Confirmation by the concurrent MS analysis of other labs that can provide only FID results, and

(3) Ability to compare GC-FID with other analytical laboratories with only GC-FID capability.

10.2 *GC/MS-SCAN-SIM System Performance Criteria*:

10.2.1 *GC/MS System Operation*:

10.2.1.1 Prior to analysis, assemble and check the GC/MS system according to manufacturer's instructions.

10.2.1.2 Table 3 outlines general operating conditions for the GC/MS-SCAN-SIM system with optional FID.

10.2.1.3 Challenge the GC/MS system with humid zero air (see 11.2.2). Results of this challenge must indicate less than 0.2 ppbv of targeted VOCs prior to sample analysis.

10.2.2 *Daily GC/MS Tuning*:

10.2.2.1 At the beginning of each day or prior to a calibration, tune the GC/MS system to verify that acceptable performance criteria are achieved.

10.2.2.2 For tuning the GC/MS, introduce gas from a cylinder containing 4-bromofluorobenzene by way of a sample loop valve injection system. Obtain a background corrected mass spectrum of 4-bromofluorobenzene and check that all key ion abundance criteria are met. BFB calibration requirements are listed in Table 4. If the criteria are not achieved, the analyst shall retune the mass spectrometer and repeat the test until all criteria are achieved. Some systems are configured for autotuning to facilitate this process.

10.2.2.3 If any key ion abundance observed for the daily 4-bromofluorobenzene mass tuning check differs by more than 10 % absolute abundance from that observed during the previous daily tuning, retune the instrument or reanalyze the sample or calibration gases, or both, until the above condition is met.

TABLE 4 4-Bromofluorobenzene Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	15 to 40 % of mass 95
75	30 to 60 % of mass 95
95	Base Peak, 100 % Relative Abundance
96	5 to 9 % of mass 95
173	<2 % of mass 174
174	>50 % of mass 95
175	5 to 9 % of mass 174
176	>95 % but <101 % of mass 174
177	5 to 9 % of mass 176

10.2.2.4 The GC/MS tuning standard may also be used to assess GC column performance (chromatographic check) and as an internal standard.

10.2.3 *GC/MS Calibration*:

10.2.3.1 *Initial Calibration*—Initially, a multipoint dynamic calibration (three to five levels plus humid zero air) is performed on the GC/MS system, before sample analysis, with the assistance of a calibration system (see Fig. 4). The calibration system uses National Institute of Standards and Technology (NIST) traceable standards or NIST/EPA CRMs in pressurized cylinders [containing a mixture of the targeted VOCs at nominal concentrations of 10 ppm by volume in nitrogen (8.2)] as working standards to be diluted with humid zero air. The contents of the working standard cylinder(s) are metered (2 mL/min) into the heated mixing chamber where they are mixed with a 2 L/min humidified zero air gas stream to achieve a nominal 10 ppbv per compound calibration mixture (see Fig. 4). This nominal 10 ppbv standard mixture is allowed to flow and equilibrate for a minimum of 24 h. After the equilibration period, the gas standard mixture is sampled and analyzed by the real-time GC/MS system (7.3.1). The results of the analyses are averaged, flow audits are performed on the mass flow meters and the calculated concentration compared to generated values. After the GC/MS is calibrated at three to five concentration levels, a second humid zero air sample is passed through the system and analyzed. The second humid zero air test is used to verify that the GC/MS system is certified clean (less than 0.2 ppbv of target compounds).

NOTE 17—Alternative approaches for generation of calibration standards are acceptable as long as the calibration range (0–100 ppbv) and humidity are accurately maintained.

10.2.3.2 As an alternative, a multipoint humid static calibration (three to five levels plus zero humid air) can be performed on the GC/MS system. During the humid static calibration analyses, three (3) passivated canisters are filled each at a different concentration between 1 to 20 ppbv from the calibration manifold using a pump and mass flow control arrangement [see Fig. 4(c)]. The canisters are then delivered to the GC/MS to serve as calibration standards. The canisters are analyzed by the MS in the SIM mode, each analyzed twice. The expected retention time and ion abundance (see Table 4 and Table 5) are used to verify proper operation of the GC/MS system. A calibration response factor is determined for each analyte, as illustrated in Table 5.

10.2.3.3 *Routine Calibration*—The GC/MS system is calibrated daily (and before sample analysis) with a one point

TABLE 5 Response Factors (ppbv/area count) and Expected Retention Time for GC-MS-SIM Analytical Configuration

Compounds	Response Factor (ppbv/area count)	Expected Retention Time (minutes)
Freon 12	0.6705	5.01
Methyl chloride	4.093	5.64
Freon 114	0.4928	6.55
Vinyl chloride	2.343	6.71
Methyl bromide	2.647	7.83
Ethyl chloride	2.954	8.43
Freon 11	0.5145	9.87
Vinylidene chloride	1.037	10.93
Dichloromethane	2.255	11.21
Trichlorotrifluoroethane	0.9031	11.50
1,1-Dichloroethane	1.273	12.50
cis-1,2-Dichloroethylene	1.363	13.40
Chloroform	0.7911	13.75
1,2-Dichloroethane	1.017	14.39
Methyl chloroform	0.7078	14.62
Benzene	1.236	15.04
Carbon tetrachloride	0.5880	15.18
1,2-Dichloropropane	2.400	15.83
Trichloroethylene	1.383	16.10
cis-1,3-Dichloropropene	1.877	16.96
trans-1,3-Dichloropropene	1.338	17.49
1,1,2-Trichloroethane	1.891	17.61
Toluene	0.9406	17.86
1,2-Dibromoethane	0.8662	18.48
Tetrachloroethylene	0.7357	19.01
Chlorobenzene	0.8558	19.73
Ethylbenzene	0.6243	20.20
m,p-Xylene	0.7367	20.41
Styrene	1.888	20.80
1,1,2,2-Tetrachloroethane	1.035	20.92
o-Xylene	0.7498	20.92
4-Ethyltoluene	0.6181	22.53
1,3,5-Trimethylbenzene	0.7088	22.65
1,2,4-Trimethylbenzene	0.7536	23.18
m-Dichlorobenzene	0.9643	23.31
Benzyl chloride	1.420	23.32
p-Dichlorobenzene	0.8912	23.41
o-Dichlorobenzene	1.004	23.88
1,2,4-Trichlorobenzene	2.150	26.71
Hexachlorobutadiene	0.4117	27.68

calibration. The GC/MS system is calibrated either with the dynamic calibration procedure [see Fig. 4] or with a 6 L passivated canister filled with humid calibration standards from the calibration manifold (see 10.2.3.2). After the single point calibration, the GC/MS analytical system is challenged with a humidified zero gas stream to ensure the analytical system returns to specification (less than 0.2 ppbv of selective organics).

10.3 *Analytical Procedures*:

10.3.1 *Canister Receipt*:

10.3.1.1 The overall condition of each sample canister is observed. Each canister must be received with an attached sample identification tag.

10.3.1.2 Each canister is recorded in the dedicated laboratory logbook. Also noted on the identification tag are date received and initials of recipient.

NOTE 18—A log containing the usage and history of each canister shall be kept. This historical record will assist in ensuring that canisters used for source sampling are not mixed with canisters used for indoor or ambient air. Samples used for high level standards or to acquire high level VOC samples should be flagged to receive individual blanking quality control checks after sample analysis.

10.3.1.3 The pressure of the canister is checked by attaching a pressure gage to the canister inlet. The canister valve is opened briefly and the pressure (kPa, psig) is recorded.

NOTE 19—If pressure is <83 kPa (<12 psig), the user may wish to pressurize the canisters, as an option, with zero grade nitrogen up to 137 kPa (20 psig) to ensure that enough sample is available for analysis. However, pressurizing the canister can introduce additional error, increase the minimum detection limit (MDL), and is time consuming. The user must consider these limitations as part of his program objectives before pressurizing. Final cylinder pressure is recorded.

10.3.1.4 If the canister pressure is increased, a dilution factor (DF) is calculated and recorded on the sampling data sheet:

$$DF = Y_a/X_a \tag{3}$$

where:

X_a = canister pressure absolute before dilution, kPa, psia and

Y_a = canister pressure absolute after dilution, kPa, psia.

After sample analysis, detected VOC concentrations are multiplied by the dilution factor to determine concentration in the sampled air.

10.3.2 *GC/MS-SCAN and SIM Analysis*:

10.3.2.1 When the MS is placed in the full scan mode (SCAN) all ions are scanned between the preset windows for monitoring. The characteristic mass spectrum of any compound or group of compounds reaching the MS detector are recorded and can be interpreted for both qualitative identification and quantitative determination. In the SIM mode of operation, the MS monitors only preselected ions, rather than scanning all masses continuously between two mass limits. As a result, increased sensitivity and improved quantitative analysis can be achieved at the expense of identifying and quantifying unknown compounds.

10.3.2.2 The analytical system shall be properly assembled, humid zero air certified (see 11.2), operated (see Table 3), and calibrated for accurate VOC determination.

10.3.2.3 The mass flow controllers are checked and adjusted to provide correct flow rates for the system.

10.3.2.4 The sample canister is connected to the inlet of the GC/MS-SCAN or GC/MS-SIM analytical system. For pressurized samples, a mass flow controller is placed on the canister, the canister valve is opened and the canister flow is vented past a tee inlet to the analytical system at a flow of 75 mL/min so that the inlet system up to the six-port sample injection valve is flushed with sample gas (typically 40 mL). The cryogenic trap is connected and verified to be operating properly while cooled with cryogen through the system.

NOTE 20—Flow rate is not as important as acquiring sufficient sample volume.

10.3.2.5 Sub-ambient pressure samples are connected directly to the inlet. Sample flow from the canister is controlled to allow sample air to pass through the concentration loop to an evacuated (lower pressure) reservoir downstream of the loop. A pressure increase in the downstream reservoir is often used to monitor the sample volume that is pulled through the loop.

10.3.2.6 The GC oven and cryogenic trap (inject position) are cooled to their set points of −50°C and −178°C, respectively.

10.3.2.7 As soon as the cryogenic trap reaches its lower set point of −178°C, the six-port chromatographic valve is turned to its fill position to initiate sample collection.

10.3.2.8 A ten-minute collection period of canister sample is utilized.

NOTE 21—More or less canister sample is used for analysis depending on the sensitivity of the mass detection unit and the concentration of the target analytes in the sample.

10.3.2.9 After the sample is preconcentrated in the cryogenic trap, the GC sampling valve is cycled to the inject position and the cryogenic trap is heated. The trapped analytes are thermally desorbed onto the head of the capillary column. The GC oven is programmed to start at −50°C and after 2 min to heat to 150°C at a rate of 8°C per minute.

10.3.2.10 Upon sample injection onto the column, the MS is signaled by the computer to start data acquisition. In the SCAN mode, the eluting carrier gas passing through the mass spectrometer source is scanned from 38 to 250 amu, resulting in a 1.5 Hz repetition rate. This corresponds to about 6 scans per eluting chromatographic peak.

10.3.2.11 The individual analyses are handled in three phases: data acquisition, data reduction, and data reporting.

10.3.2.12 Primary identification is based upon retention time and relative abundance of eluting ions as compared to the spectral library stored on the hard disk of the GC/MS data computer. In the SIM, the data acquisition software is set to monitor specific compound fragments at specific times in the analytical run. Data reduction is coordinated by the postprocessing program that is automatically accessed after data acquisition is completed at the end of the GC run. Resulting ion profiles are extracted, peaks are identified and integrated, and an integration report is generated by the computer software. A reconstructed ion chromatogram for hard copy reference is prepared by the program and various parameters of interest such as time, date, and integration constants are printed. At the completion of the program, the data reporting software is accessed. The appropriate calibration table is retrieved by the data reporting program from the computer's hard disk storage and the proper retention time and response factor parameters are applied to the macro program's integration file. With reference to certain pre-set acceptance criteria, peaks are automatically identified and quantified and a final summary report is prepared.

10.3.2.13 The concentration (ppbv) is calculated using the previously established response factors (see 10.2.3.2), as illustrated in Table 5.

NOTE 22—If the canister is diluted before analysis, an appropriate multiplier is applied to correct for the volume dilution of the canister (10.3.1.4).

10.3.2.14 In a typical analysis, approximately 64 min are required for each sample analysis, 15 min for system initialization, 14 min for sample collection, 30 min for analysis, and 5 min for post run equilibration, during which a report is printed.

11. Cleaning and Certification Program

11.1 *Canister Cleaning and Certification*:

11.1.1 All canisters must be clean and free of any contaminants before sample collection.

11.1.2 All canisters are leak tested by pressurizing them to approximately 200 kPa (30 psig) with zero air.

NOTE 23—The canister cleaning system in Fig. 3 can be used for this task. The initial pressure is measured, the canister valve is closed, and the final pressure is checked after 24 h. If leak tight, the pressure shall not vary more than ±13.8 kPa (±2 psig) over the 24–h period.

11.1.3 A canister cleaning system may be assembled as illustrated in Fig. 3. Cryogen is added to both the vacuum pump and zero air supply traps. The canister(s) are connected to the manifold. The vent shut-off valve and the canister valve(s) are opened to release any remaining pressure in the canister(s). The vacuum pump is started and the vent shut-off valve is then closed and the vacuum shut-off valve is opened. The canister(s) are evacuated to less than 0.0064 kPa (0.05 mm Hg) for at least one hour.

NOTE 24—On a daily basis, or more often if necessary, the cryogenic traps shall be purged with zero air to remove any trapped water from previous canister cleaning cycles.

11.1.4 The vacuum and vacuum/pressure gage shut-off valves are closed and the zero air shut-off valve is opened to pressurize the canister(s) with humid zero air to approximately 200 kPa (30 psig). If a zero gas generator system is used, the flow rate may need to be limited to maintain the zero air quality.

11.1.5 The zero shut-off valve is closed and the canister(s) is allowed to vent down to atmospheric pressure through the vent shut-off valve. The vent shut-off valve is closed. Steps 11.1.3-11.1.5 are repeated two additional times for a total of three evacuation/pressurization cycles for each set of canisters.

11.1.6 At the end of the evacuation/pressurization cycle, the canister is pressurized to 200 kPa (30 psig) with humid zero air. Analyze the canister with the GC/MS or GC-FID-ECD analytical system. Any canister that has not tested clean (compared to direct analysis of humidified zero air of less than 0.2 ppbv of targeted VOCs) shall not be used. As a "blank" check of the canister(s) and cleanup procedure, analyze the final humid zero air fill of 100 % of the canisters until the cleanup system and canisters are proven reliable (less than 0.2 ppbv of target VOCs). This blank check may be reduced to one canister per batch after the blank criterion has been met on one entire batch.

11.1.7 Reattach the canister to the manifold and reevacuate to less than 0.0064 kPa (0.05 mm Hg). The canister valve is closed. Remove the canister from the cleaning system and cap the canister connection with a stainless steel fitting. The canister is now ready for collection of an air sample. Attach an identification tag to the neck of each canister for field notes and chain-of-custody purposes. Retain the canister in this condition until used.

11.1.8 As an option to the humid zero air cleaning procedures, heat the canisters in an isothermal oven to no greater than 100°C using the apparatus described in 11.1.3.

NOTE 25—For sampling heavier, more complex VOC mixtures, the canisters shall be heated to 250°C during 11.1.3-11.1.7. Canister valves shall not be heated during this cleaning process. Once heated, the canisters are evacuated to 0.0064 kPa (0.05 mm Hg). At the end of the heated/evacuated cycle, pressurize the canisters with humid zero air and analyze by the blanking procedures in this standard. Any canister that has not tested clean (less than 0.2 ppbv of targeted compounds) shall not be used. Once tested clean, reevacuate the canisters to 0.0064 kPa (0.05 mm Hg) or less and retain in the evacuated state until used. Repeated heating of canisters may degrade the treated surface of the canister and premature degradation of samples may ensue. Periodic (yearly) check of calibration standard stability shall be performed in canisters that are repeatedly heat treated.

11.2 *Sampling System Cleaning and Certification*:

11.2.1 *Cleaning Sampling System Components*:

11.2.1.1 Sample components are disassembled and cleaned before the sampler is assembled. Nonmetallic parts are rinsed with HPLC grade deionized water and dried in a vacuum oven at 50°C. Typically, stainless steel parts and fittings are cleaned by placing them in a beaker of hexane in an ultrasonic bath for 15 min. This procedure is repeated with methanol as the solvent.

11.2.1.2 The parts are then rinsed with HPLC grade deionized water and dried in a vacuum oven at 100°C for 12 to 24 h.

11.2.1.3 Once the sampler is assembled, the entire system is purged with humid zero air for 24 h.

11.2.2 *Humid Zero Air Certification*:

11.2.2.1 The system is "certified" if less than 0.2 ppbv of targeted compounds is measured for each compound when the system is challenged with the ultra high purity humidified air test stream. The cleanliness of the sampling system is determined by testing the sampler with humid zero air with an evacuated canister, as follows.

11.2.2.2 The calibration system and manifold are assembled as illustrated in Fig. 4. The sampler (with an evacuated sampling canister) is connected to the manifold and the zero air cylinder activated to generate a humid gas stream (2 L/min) to the calibration manifold.

11.2.2.3 The humid zero gas stream passes through the calibration manifold, through the sampling system and is collected in a clean evacuated sampling canister. If the sampler passes the humid zero air test, it is then tested with humid calibration gas standards containing selected VOCs at concentration levels expected in field sampling (for example, 5.0 to 20 ppbv) as outlined in 11.2.3.

NOTE 26—As an alternative to save the use of GC/MS time, a GC-FID-ECD may be used for canister analysis of certification standards. Such a system must include a sample concentration interface identical to the one used for GC/MS analysis (10.3). It must also be calibrated with standards prepared in the same way as those used for GC/MS analysis. Retention time is verified with known standard compounds.

11.2.3 *Sampler System Certification with Humid Calibration Gas Standards*:

11.2.3.1 Assemble the dynamic calibration system and manifold as illustrated in Fig. 4.

NOTE 27—The certification manifold will often become contaminated with certification compounds in the process of certifying samplers. Separate manifolds shall be used for zero certification and humid calibration gas challenge to avoid erroneous results caused by carryover of compounds in the test manifold. Alternatively, one manifold may be used; however, the manifold must be certified as clean prior to the start of a zero certification test.

NOTE 28—Manifold components and flow regulators must be heated during humid calibration gas standards certification to ensure complete vaporization of challenge gas components.

11.2.3.2 Verify that the calibration system is clean (less than 0.2 ppbv of targeted compounds) by sampling a humidified gas stream, without gas calibration standards, with a previously certified clean canister (see 11.1).

11.2.3.3 The assembled dynamic calibration system is certified clean if less than 0.2 ppbv of targeted compounds are found.

11.2.3.4 For generating the humidified calibration standards, the calibration gas cylinder(s) (see 8.2) containing nominal concentrations of 10 ppm by volume in nitrogen of selected VOCs are attached to the calibration system. The gas cylinders are opened and the gas mixtures are passed through 0 to 50 mL/min certified mass flow controllers to generate ppbv levels of calibration standards.

11.2.3.5 After the appropriate equilibration period, attach the sampling system (containing a certified evacuated canister) to the manifold, as illustrated in Fig. 4.

11.2.3.6 Sample the dynamic calibration gas stream with the sampling system according to 9.2.

11.2.3.7 Concurrent with the sampling system operation, real time monitoring of the calibration gas stream is accomplished by collection of a canister sample connected directly to a mass flow controller and the certification test gas feed line. Analysis of this check sample must be performed to confirm the concentration of standard gas delivered to the samplers being certified.

11.2.3.8 At the end of the sampling period (normally same time period used for anticipated sampling), the sampling system canister is analyzed and compared to the reference canister results to determine if the concentration of the targeted VOCs was increased or decreased by the sampling system.

11.2.3.9 A recovery of between 85 % and 115 % is expected for the average of all targeted VOCs. Individual compounds must fall within the range of 80 % and 120 % for acceptable certification.

12. Performance Criteria and Quality Assurance

12.1 *Standard Operating Procedures (SOPs)*:

12.1.1 SOPs must be generated in each laboratory describing and documenting the following activities: (*1*) assembly, calibration, leak check, and operation of specific sampling systems and equipment used, (*2*) preparation, storage, shipment, and handling of samples, (*3*) assembly, leak-check, calibration, and operation of the analytical system, addressing the specific equipment used, (*4*) canister storage and cleaning, and (*5*) all aspects of data recording and processing, including lists of computer hardware and software used.

12.1.2 Specific stepwise instructions should be provided in the SOPs and should be readily available to and understood by the laboratory personnel conducting the work.

12.2 *Method Relative Accuracy and Linearity*:

12.2.1 Accuracy can be determined by injecting VOC standards (see 8.2) from an audit cylinder into a sampler. The contents are then analyzed for the components contained in the audit canister. Percent relative accuracy is calculated:

$$\% \text{ Relative Accuracy} = (X - Y)/X \times 100 \qquad (4)$$

where:

Y = concentration of the targeted compound recovered from sampler, and

X = concentration of VOC-targeted compound in the NIST-SRM or EPA-CRM audit cylinders.

12.2.2 If the relative accuracy does not fall between 80 and 120 %, the sampler should be removed from use, cleaned, and recertified according to initial certification procedures outlined in 11.2.2 and 11.2.3.

12.3 *Method Modification*:

12.3.1 *Sampling*:

12.3.1.1 *Urban Air Toxics Sampler*—The sampling system described in this test method (Fig. 1) may be modified like the sampler in EPA's FY-90 Urban Air Toxics Pollutant Program (see Fig. 6).

12.3.1.2 *Analysis*:

(1) Heat inlet tubing from the calibration manifold to 50°C (same temperature as the calibration manifold) to prevent condensation on the internal walls of the system.

(2) The analytical strategy for this test method involves positive identification and quantitation by GC/MS-SCAN or -SIM mode. This is a highly specific and sensitive detection technique. Because a specific detector system (GC/MS-SCAN or -SIM) is more complicated and expensive than the use of non-specific detectors (GC-FID-ECD-PID), the analyst may perform a screening analysis and preliminary quantitation of VOC species in the sample, including any polar compounds, by utilizing the GC-multidetector (GC-FID-ECD-PID) analytical system prior to GC/MS analysis. This multidetector system can be used for approximate quantitation. The GC-FID-ECD-PID provides a "snapshot" of the constituents in the sample, allowing the analyst to determine:

(a) Whether the constituents are within the calibration range of the anticipated GC/MS-SCAN-SIM analysis or does the sample require further dilution, and

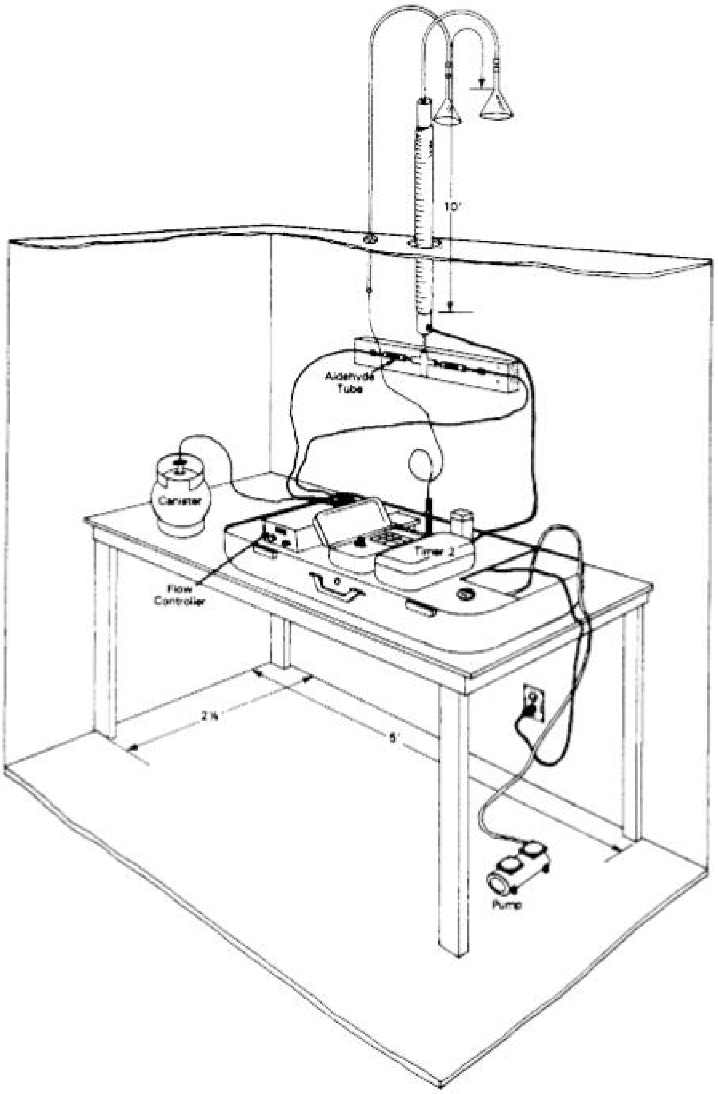


FIG. 6 Perspective View of UATMP Sampler

(b) Are there unexpected peaks which need further identification through GC/MS-SCAN or will GC/MS-SIM be adequate.

12.4 *Quality Assurance (See Fig. 7)*:

12.4.1 *Sampling System*:

12.4.1.1 Paragraph 9.2 requires pre- and post-sampling measurements with a certified mass flow controller for flow verification of sampling system.

12.4.1.2 Paragraph 11.1 requires all canisters to be pressure tested to 200 kPa ± 14 kPa (30 psig ± 2 psig) over a period of 24 h.

12.4.1.3 Paragraph 11.1 requires that all canisters be certified clean (containing less than 0.2 ppbv of targeted VOCs) through a humid zero air certification program.

12.4.1.4 Paragraph 11.2.2 requires all sampling systems to be certified initially clean (containing less than 0.2 ppbv of targeted VOCs) through a humid zero air certification program.

12.4.1.5 Paragraph 11.2.3 requires all sampling systems to pass an initial humidified calibration gas certification [at VOC concentration levels expected in the field (for example, 0.5 to 20 ppbv)] with a percent recovery of greater than 90.

12.4.2 *GC/MS-SCAN-SIM System Performance Criteria*:

12.4.2.1 Paragraph 10.2.1 requires the GC/MS analytical system to be certified clean (less than 0.2 ppbv of targeted VOCs) prior to sample analysis, through a humid zero air certification.

12.4.2.2 Paragraph 10.2.2 requires the tuning of the GC/MS with 4-bromofluorobenzene (4-BFB) and that it meets the key ions and ion abundance criteria outlined in Table 4.

12.4.2.3 Paragraph 10.2.3 requires both an initial multipoint humid static calibration (three levels plus humid zero air) and a daily calibration (one point) of the GC/MS analytical system.

12.4.2.4 Paragraph 10.2.3.3 requires that a calibration check sample in the mid range of the calibration curve is analyzed once each day or once every eight samples to ensure the calibration of the GC/MS is still valid and under control.

13. Precision and Bias

13.1 The precision of replicate gas sample analysis will vary depending on the volatile organic compound being determined. Typical precision reported as %CV should be ±30 %, for determinations made on the same sample over an 8-h period. If the GC/MS analysis does not meet or exceed these criteria, the instrument should be retuned and recalibrated. Precision measured for seven replicate analyses analyzed over a 10-h period are reported in Table 6.

13.2 Tests performed to measure the bias of this procedure have been conducted with a performance audit sample prepared by U.S. EPA and referenced to a primary standard gas mixture prepared by NIST. Humidified gas performance standards were analyzed in a GC/MS system configured in accordance with this standard, following the procedure without the

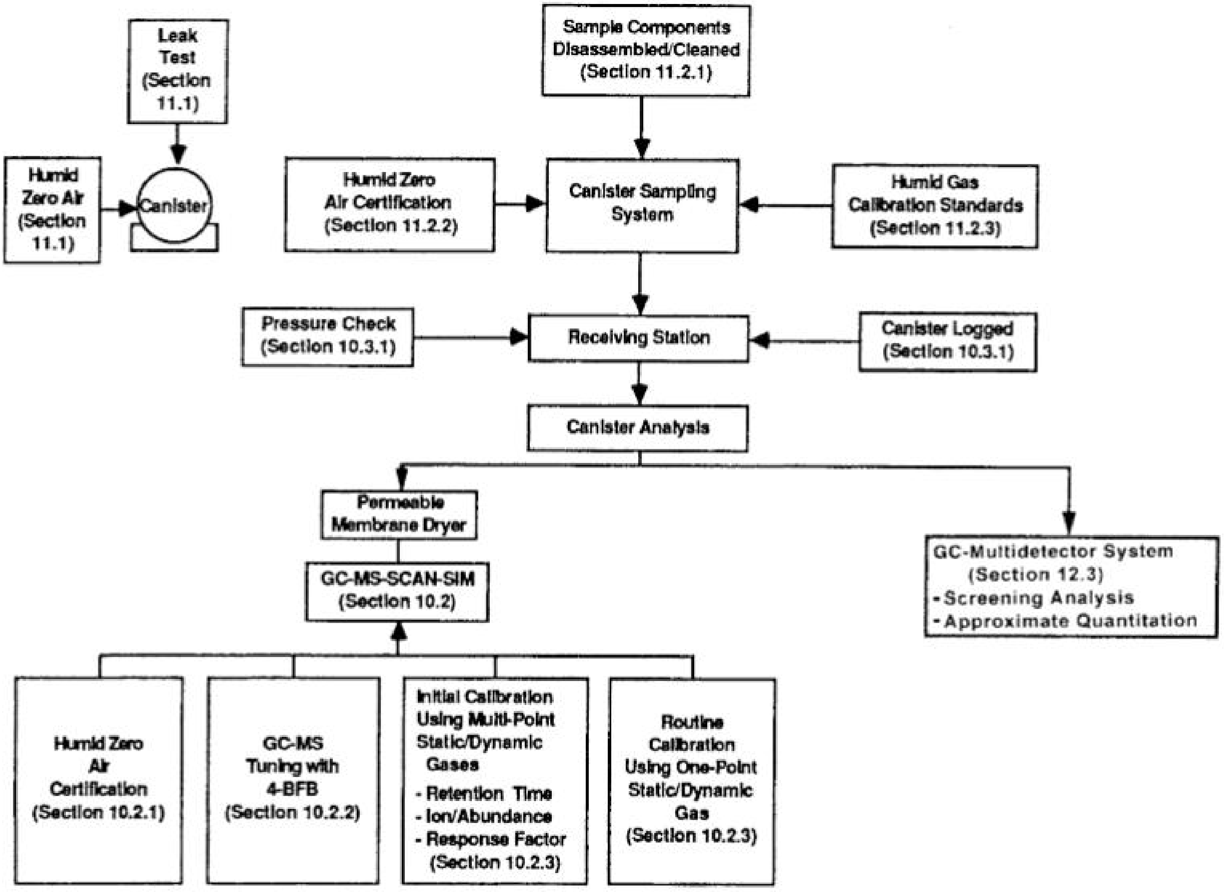


FIG. 7 System Quality Assurance/Quality Control (QA/QC) Activities Associated with Various Analytical Systems

TABLE 6 Precision Results for Canister VOC Method (Example)

Compound	Standard Deviation	% CV	Instrument Detection Limit
1,3-Butadiene	0.15	12.5	0.20
Vinyl chloride	0.11	12.3	0.38
Propylene	0.18	16.8	0.95
Chloromethane	0.13	12.4	0.48
Chloroethane	0.12	7.8	0.56
Bromomethane	0.07	18.5	0.22
Methylene chloride	0.44	49.7	0.23
trans-1,2-Dichloroethane	0.22	16.4	0.66
1,1-Dichloroethane	0.08	6.3	0.26
Chloroprene	0.08	8.2	0.26
Bromochloromethane	0.06	4.3	0.23
Chloroform	0.26	6.1	0.81
1,1,1-Trichloroethane	0.20	15.9	0.72
Carbon tetrachloride	0.03	9.2	0.09
Benzene	0.04	9.0	0.12
1,2-Dichloroethane	0.08	5.2	0.21
Trichloroethene	0.04	14.0	0.15
1,2-Dichloropropane	0.07	6.1	0.16
Bromodichloromethane	0.14	9.7	0.46
trans-1,3-Dichloropropene	0.07	5.7	0.23
Toluene	0.17	24.5	0.52
n-Octane	0.32	22.7	1.01
cis-1,3-Dichloropropene	0.05	8.4	0.14
1,1,2-Trichloroethane	0.31	12.0	0.96
Tetrachloroethene	0.08	19.0	0.27
Dibromochloromethane	0.04	26.3	0.11
Chlorobenzene	0.07	7.5	0.22
Ethylbenzene	0.23	7.9	0.73
m-/*p*-Xylene	0.41	11.1	1.03
Styrene	0.15	37.9	0.46
o-Xylene	0.23	16.2	0.71
Bromoform	0.03	6.5	0.10
1,1,2,2-Tetrachloroethane	0.09	6.7	0.22
m-Dichlorobenzene	0.09	8.7	0.27
p-Dichlorobenzene	0.04	12.9	0.11
o-Dichlorobenzene	0.14	8.9	0.38
1,1-Dichloroethene	0.05	4.2	0.17
1,2-Dichloroethane	0.08	6.7	0.24
cis-1,2-Dichloroethene	0.06	5.0	0.19
Freon 11 (Trichlorofluoromethane)	0.06	4.8	0.18
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	0.06	5.3	0.20
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	0.09	7.5	0.27
Freon 12 (Dichlorodifluoromethane)	0.08	6.9	0.26
Acetonitrile	0.20	16.7	0.63
Acrylonitrile	0.09	7.2	0.27
Benzyl chloride	0.06	4.8	0.18
4-Ethyltoluene	0.13	10.9	0.41
1,2,4-Trichlorobenzene	0.32	26.8	1.01
1,2,4–Trimethylbenzene	0.17	13.8	0.52
1,3,5–Trimethylbenzene	0.13	10.6	0.40
Hexachloro-1,3-butadiene	0.32	16.8	1.01

use of a permeable membrane dryer. Four performance samples ranging in concentration from 2 to 10 ppbv were analyzed over a period of 10 months. The test results shown in Tables 7 and 8 were obtained using this system.

TABLE 7 NIST Traceable GC/MS Audit Results

Compound	Audit #1164			Audit #1252			Audit #1366			Audit #1496		
	Ref. (ppbv)	Rep. (ppbv)	% Bias	Ref. (ppbv)	Rep. (ppbv)	% Bias	Ref. (ppbv)	Rep. (ppbv)	% Bias	Ref. (ppbv)	Rep. (ppbv)	% Bias
Vinyl chloride	3.6	2.8	−22.0	4.9	4.5	−8.16	3.6	3.2	−11.11	2.4	2.1	−12.20
Bromomethane	3.6	3.5	−2.8	4.8	4.2	−12.50	3.5	3.1	−11.43	2.4	1.1	−54.17^A
Methylene chloride	7.2	7.9	4.2	9.8	9.1	−7.14	7.2	6.7	−6.94	4.9	5.6	14.29
trans-1,2-Dichloroethylene	6.9	7.0	1.4	9.3	7.6	−18.28	7.6	5.4	−20.59	4.9	5.1	8.51
1,1-Dichloroethane	3.8	3.3	−13.0	5.1	3.9	−23.53	3.9	2.9	−27.03	2.6	2.6	0.00
Chloroform	3.5	3.8	8.6	4.8	5.4	12.50	3.5	4.3	22.86	2.4	2.9	20.83
1,1,1-Trichloroethane	3.6	4.1	14.0	4.8	4.9	2.08	3.6	4.0	11.11	2.4	2.7	12.50
Carbon tetrachloride	3.3	3.4	3.0	4.5	3.6	−20.00	3.3	3.7	12.12	2.3	2.6	13.04
Benzene	7.3	7.0	−4.1	9.9	10.5	6.06	7.3	8.2	12.33	4.9	4.5	−8.16
Trichloroethylene	3.6	3.6	0.0	10.0	10.1	1.00	3.6	6.0	66.67	2.4	2.1	−12.50
1,2-Dichloropropane	7.4	7.2	−2.7	4.9	5.9	20.41	7.3	8.8	20.55	5.0	4.1	−18.00
Toluene	3.8	4.1	7.9	5.1	4.6	−9.80	3.8	3.6	−5.26	2.6	2.5	−3.85
Tetrachloroethylene	3.8	5.3	39.0^A	5.2	5.6	7.69	3.8	4.6	21.05	2.6	2.8	7.69
Chlorobenzene	7.6	9.5	25.0	10.3	6.6	−35.92^A	7.5	5.5	−26.67	5.1	4.4	−13.72
Styrene	3.7	2.0	−46.0^A	5.0	4.6	−8.00	3.7	0.5	−86.49	2.5	2.4	−4.00
o-Xylene	8.8	8.0	−9.1	12.0	8.9	−25.83	8.8	6.9	−21.59	6.0	6.1	1.67
Ethylbenzene	7.8	6.8	−13.0	10.5	7.2	−31.43	7.7	5.7	−25.97	5.3	5.1	−3.77

^A Greater than the ±30 % data quality objectives.

TABLE 8 Average Performance on Audits

	Average Deviation	Standard	n
Vinyl chloride	−3.9	14.4	8
Bromomethane	5.5	19.7	8
Methylene chloride	5.9	9.9	8
trans-1,2-Dichloroethylene	−4.2	10.9	8
1,1-Dichloroethane	−7.9	12.5	8
Chloroform	15.9	5.3	5
1,1,1-Trichloroethane	8.9	5.6	8
Carbon tetrachloride	6.0	12.6	8
Benzene	5.6	12.5	8
Trichloroethylene	9.1	24.2	8
1,2-Dichloropropane	7.0	15.0	8
Toluene	1.6	12.3	8
Tetrachloroethylene	18.3	15.1	7
Chlorobenzene	4.2	22.4	6
Styrene	25.7	30.9	7
o-Xylene	−13.7	10.8	4
Ethylbenzene	−13.7	9.7	8

14. Keywords

14.1 ambient atmospheres; analysis; atmospheres; canister sampling; gas chromatography–mass spectrometry; indoor atmospheres; sampling; volatile organic compounds; workplace atmospheres

REFERENCES

(1) Oliver, K.D., Pleil, J.D., and McClenny, W.A., "Sample Integrity of Trace Level Volatile Organic Compounds in Ambient Air Stored in SUMMA® Polished Canisters," *Atm. Environ.*, 20: 1403–1411, 1986.

(2) Holdren, M.W., and Smith, D.L., "Stability of Volatile Organic Compounds While Stored In SUMMA® Polished Stainless Steel Canisters," Final Report, EPA Contract No. 68–02–4127, Research Triangle Park, NC, Battelle Columbus Laboratories, January, 1986.

(3) Kelly, T.J., and Holdren, M.W., "Applicability of Canisters for Sample Storage in the Determination of Hazardous Air Pollutants," *Atm. Environ.*, 29: 2595–2608, 1995.

(4) Brymer, D.A., Ogle, L.D., Jones, C.J., and Lewis, D.L., "Viability of Using SUMMA® Polished Canisters for the Collection and Storage of Parts per Billion by Volume Level Volatile Organics," *Environ. Sci. Technol.*, 30: 188–195, 1996.

(5) Pate, B., Jayanty, R.K.M., Peterson, M., Evans, G.F., "Temporal Stability of Polar Organic Compounds in Stainless Steel Canisters," *J. Air Waste Manage. Assoc.*, 42: 460–462, 1992.

(6) Kelly, T.J., Callahan, P.J., Pleil, and Evans, G.F., "Method Development and Field Measurements for Polar Volatile Organic Compounds in Ambient Air," *Environ. Sci. Technol.*, 27: 1146–1153, 1993.

(7) Coutant, R.W., and McClenny, W.A., "Competitive Adsorption Effects and the Stability of VOC and PVOC in Canisters," Proceedings of the 1991 U.S. EPA/AW&MA International Symposium on Measurement of Toxic and Related Air Pollutants, May, 1991, A&WMA Publication VIP-21, EPA 600/9–91/018.

(8) McClenny, W. A., Pleil, J. D., Lumpkin, T. A., and Oliver, K. D.,

"Update on Canister-Based Samplers for VOCs," *Proceedings of the 1987 EPA/APCA Symposium on Measurement of Toxic and Related Air Pollutants*, May, 1987, APCA Publication VIP-8, EPA 600/9-87-010.

(**9**) Dayton, D-P., Brymer, D. A., and Jongleux, R. F.," Canister Based Sampling Systems—A Performance Evaluation," *Proceedings of the 1990 EPA/APCA Symposium on Measurement of Toxic and Related Air Pollutants*, May, 1990 APCA Publication VIP-17, EPA 600/9-90/026.

(**10**) Crist, H. L., "Assessing the Performance of Ambient Air Samplers for Volatile Organic Compounds," in *Monitoring Methods for Toxics in the Atmosphere, ASTM STP 1052*, W. L. Zielinski, Jr., and W. D. Dorko, Eds., ASTM, Philadelphia, PA, 1990, pp. 46–52.

(**11**) Rasmussen, R.A., and Lovelock, J.E., "Atmospheric Measurements Using Canister Technology," *J. Geophysical Research*, 83: 8369–8378, 1983.

(**12**) Lonneman, W.A., Seila, R.L., and Meeks, S.A., "Non-Methane Organic Composition in the Lincoln Tunnel," Environ. Sci. Technol., 20:790–796, 1986.

(**13**) McClenny, W.A., Pleil, J.D., Evans, G.F., Oliver, K.D., Holdren, M.W., and Winberry, W.T., "Canister-Based Method for Monitoring Toxic VOCs in Ambient Air," *J. Air Waste Manage. Assoc.*, 41: 1308–1318, 1991.

(**14**) Dayton, D.P., and Swift, J., "Support for NMOC/SNMOC, UATMP, and PAMS Networks- Quality Assurance Project Plan," Special Report by Environmental Research Group under EPA Contract Number 68–D-99–007, Research Triangle Park, NC, May 2001 available from Vickie Presnell, MD-14, USEPA, Research Triangle Park, NC 27711.

(**15**) McClenny, W.A., Pleil, J.D., Holdren, J.W., and Smith, R.N., "Automated Cryogenic Preconcentration and Gas Chromatographic Determination of Volatile Organic Compounds," *Analytical Chemistry*, 56:2947, 1984.

(**16**) Helmig, D. and Greenberg, J.P., "Automated In-Situ Gas Chromatographic-Mass Spectrometric Analysis of PPT Level Volatile Organic Trace Gases using Multistage Solid-Adsorbent Trapping," *J. Chromatog. A.*, 677: 123–132, 1994.

(**17**) Oliver, K.D., Adams, J.R., Daughtrey, Jr., E.H., McClenny, W.A., Yoong, M.J., Pardee, M.A., Almasi, E.B., and Kirshen, N.A., "Techniques for Monitoring Toxic VOCs in Air: Sorbent Preconcentration, Closed-Cell Cooler Cryofocusing, and GC/MS Analysis," *Environ. Sci. Technol.*, 30: 1939–1945, 1996.

(**18**) Seila, R.L., Lonneman, W.A., and Meeks, S.A., "Determination of C2 to C12 Ambient Air Hydrocarbons in 39 U.S. Cities, from 1984 through 1986," EPA/600/S3–89/058, USEPA, Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, September 1989.

(**19**) McElroy, F. F., Thompson, V. L., and Richter, H. G., *A Cryogenic Preconcentration—Direct FID (PDFID) Method for Measurement of NMOC in the Ambient Air*, EPA-600/4-85-063, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1985.

(**20**) Pleil, J.D., Oliver, K.D., and McClenny, W.A., "Enhanced Performance of Nafion Dryers in Removing Water from Air Samples Prior to Gas Chromatographic Analysis," *J. Air Pollut. Control Assoc.*, 37: 244–248, 1987.

(**21**) Gong, Q., and Demerjian, K.L., "Hydrocarbon Losses on a Regenerated Nafion Dryer," *J. Air & Waste Manage. Assoc.*, 45: 490–493, 1995.

(**22**) McClenny, W.A., Schmidt, S.M., and Kronmiller, K.G., "Variation of the Relative Humidity of Air Released from Canisters after Ambient Sampling," *J. Air & Waste Manage. Assoc.*, 49: 64–69, 1999.

Appendix C: Community Air Monitoring Plan (CAMP)

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 D: Personnel

Senior Project Manager and Associate

Michael Miner, PE, BCEE

Experience Summary

Michael Miner has over 19 years of broad-based project management and technical experience on complex projects involving remedial investigations (RI); feasibilities studies (FS); treatability studies and pilot tests; civil, process, and mechanical design; fate and transport assessments; in-situ remediation; monitored natural attenuation; risk-based site closure and construction; verification testing; and operation, maintenance, monitoring, and optimization. He has managed numerous hours of construction and O&M work on remediation projects at refineries and other industrial sites without an OSHA recordable injury. Mr. Miner even received a “Flawless Execution” Safety Award in 2011 from a confidential petrochemical client for safe delivery of approximately 36,000 construction man-hours.

Prior to joining BC, Mr. Miner served as project manager, environmental engineer, and construction/O&M manager on projects for federal (EPA Region 2, USACE Kansas City District), public sector (NYSDEC, NYCDEP, and the City of Nashua, NH), and Fortune 200 industrial (primarily in the oil/gas, aerospace and chemical sectors) clients. He co-authored a poster for the 2008 Battelle Conference, and co-authored and delivered a presentation at the 2009 International Petroleum and Bio-fuels Environmental Conference on in-situ, thermally-enhanced extraction using steam for residual LNAPL and CVOC removal.

Assignment

Project Manager

Education

M.S., Environmental Engineering, Stevens Institute of Technology, 1995

B.S., Environmental Engineering, Stevens Institute of Technology, 1992

Registrations

Registered Professional Engineer: New Jersey, New York, Pennsylvania

National Council of Examiners for Engineers & Surveyors (NCEES): PE Record

Board Certified Environmental Engineer (BCEE): American Academy of Environmental Engineering

Certifications

OSHA 40-hour HAZWOPER & 10-hour Construction Safety Certification

Loss Prevention System (LPS) Certification

RCRA/DOT Hazardous Material Management Certification

Transit Worker Identification Credential (TWIC) Certification

Experience

19 Years

Joined Firm

2012

Select Project Experience

Groundwater Remediation System Construction and Startup, Confidential Petrochemical Client, Petrochemical Refinery, New Jersey

Project Manager. Completed construction and startup for a 150 gpm collection and treatment system for petroleum product and contaminated groundwater within a 40+ acre landfill area contained by a low-permeable cap and slurry wall. The collection system included 21 well locations, which had separate pumps for groundwater extraction and localized product extraction/storage. The treatment system consisted of an 8,000-gallon equalization tank and packaged treatment system for oil removal and discharge to the refinery WWTP. The remediation system included process instrumentation and controls to support O&M with limited operator supervision. Communication between the treatment system and extraction wells was completed via fiber optic network. Much of the work was completed using off-site modular/pre-fabricated shop construction (e.g., packaged plant, pre-cast concrete vaults, shop-welded stainless steel pipe assemblies) to optimize the construction operation and minimize on-site work effort/risks. The helical pile structural support system was delivered on a design-build basis. More than 44,000 man-hours of on-site construction work were completed without a recordable injury.

Industrial Wastewater Treatment, Confidential Client, Petrochemical Storage/Blending/Movement Terminal, New Jersey

Project Engineer. Completed the design of a 2,100-gpm facility as well as pump station upgrades for treatment of stormwater runoff and remediation groundwater at a petrochemical facility. The treatment process included flow equalization, oil/water separation, up-flow continuous-backwash sand filtration, and activated carbon adsorption for reduction of VOCs, petroleum hydrocarbons, and TSS. Designed the treatment process and facility components, including a pre-engineered building, foundation, and soil improvement system consisting of Controlled Modulus Columns (CMCs [performance-based design]). Industrial treatment works approval (TWA) and soil erosion and sediment control (SESC) permit applications were also prepared for the owner.

Groundwater Remediation Design and Design/Build Contracting, Confidential Aerospace Client, Ohio

Project Engineer. Completed the pre-design investigation and developed a performance-based, design/build contract scope of work for implementation of a 220-foot long, 25-foot deep zero-valent iron (ZVI) permeable reactive barrier (PRB) to remediate chlorinated VOCs (1,1,1-TCA, PCE, TCE, related decay products) in groundwater at an active private airport, and assisted the client with the contractor procurement process. The PRB application involved a shallow, unconsolidated water bearing unit, consisting of low-permeable glacially-deposited silt/clay with sand/gravel lenses, using hydrofracturing and/or trenching/backfill emplacement methods.

Groundwater RI/FS and Remediation System O&M, Confidential Aerospace Client, Ohio

O&M Manager. Manage O&M of two groundwater remediation facilities for hydraulic containment and recovery of chlorinated VOCs (1,1,1-TCA, PCE, TCE, related decay products) at a private airport and an aerospace product manufacturing facility. Groundwater is recovered using collection trenches and treated by bag filtration, air stripping, and hardness sequestrant addition. Also led completion of site investigations and focused feasibility studies.

Groundwater Remediation System Design/Construction/Startup , Confidential Petrochemical Client, Petrochemical Refinery, New Jersey

Project Engineer. Completed design, construction, and startup of 600-foot long by 20-foot deep groundwater interceptor trench and barrier wall system for hydraulic control and treatment of groundwater impacted by petroleum products. The barrier wall and interceptor trench were constructed using the biopolymer slurry excavation method. The barrier was constructed using inter-locking 80-mil HDPE sheets, which were keyed into an underlying till unit and sealed with a concrete plug constructed by in-situ grout injection. The collection trench was constructed using slotted HDPE collection pipe and engineered permeable filter material, which drained to a HDPE collection manhole/sump and is pumped to a process sewer system for treatment at the refinery WWTP. Due to property access constraints, construction was completed within a surface water body using a temporary construction platform and portable dam system. Two unregistered USTs were also encountered during construction, which were removed and closed in accordance with NJDEP requirements. More than 21,000 man-hours of on-site construction work were completed without a recordable injury. System has been in operation for 3 years and consistently achieved remedial performance criteria with minimal routine O&M effort.

Soil and Groundwater Remediation using Steam-enhanced Extraction ($12M), Confidential Aerospace Client, Pennsylvania

Owners Engineer and Construction Manager. Supported the implementation of a soil and groundwater remedy involving steam-enhanced extraction of petroleum product and chlorinated VOCs at a former steel products manufacturing facility. Led completion of a performance-based contract for turn-key remediation services, including detailed design, construction, and O&M to remedy completion. Assisted the client with the RA contractor procurement and selection process, and served lead construction management and quality assurance activities for multiple contractors from remedy implementation through completion. The remedy was completed using rental equipment, and the treatment process included oil/water separation, air stripping, liquid-phase activated carbon adsorption, and offgas treatment (thermal oxidation, wet scrubbing). Soil vapors and fluids were extracted from the subsurface using a combination of submersible pneumatic pumps (groundwater), high-vacuum extraction (all fluids), and soil vapor extraction (vapor). The unsaturated and saturated zones were heated to an average temperature of >94 C. More than 100,000 pounds of residual petroleum product and 21,000 pounds of chlorinated VOCs were removed during the RA; 90 percent of the VOC mass was removed in 3 months.

Soil and Groundwater Investigation and Remediation, Confidential Aerospace Client, Pennsylvania

Project Engineer. Completed concurrent remedial investigation and remedial action activities as part of an accelerated and optimized voluntary site closure strategy under the PA Act 2 regulations. The site is a former steel manufacturing facility with LNAPL (fuels, cutting oils) and CVOC (TCE, 1,1,1-TCA, biotic and abiotic decay products) impacts to soil and groundwater. Client sold the property for re-development and retained responsibility environmental impacts. Provided O&M support and performed routine groundwater monitoring for an existing groundwater extraction and treat system. Completed the remedial investigation, human health risk assessment, and screening-level ecological risk assessment and prepared the cleanup plan. The project scope encompassed unconsolidated and multi-layered bedrock units, both on and off site. Work included development and application of a three-dimensional groundwater flow model and a four dimensional environmental visualization/geo-statistical analysis system using mining visualization software for groundwater characterization, fate and transport assessment, and design/implementation/optimization of a steam-enhanced extraction interim remedial measure. Calculated site-specific, transport- and risk-based cleanup goals for subsurface soils and groundwater and successfully closed out PADEP concerns regarding the potential for DNAPL in fractured bedrock. Advanced the site from RI to the post-RA attainment demonstration phase in 2009, and anticipate completion of the attainment demonstration process in 2012.

Remedial Investigation and Action, Confidential Chemical Manufacturing Client, Former Chemical Manufacturing Facility, Passaic County, New Jersey

Senior Engineer and Technical Support. Supported concurrent RI and RA activities involving CVOC (PCE and biological decay products) and chlorobenzene (multiple isomers) impacts to unconsolidated and multi-layered bedrock units, both on and off site. Assisted with evaluations and on-going optimization of the existing groundwater extraction and treatment system, which was operating at less than 50 percent of its capacity due to iron and manganese precipitation/scaling issues. Completed SOW development and procurement for design/build VI mitigation services at off-site properties. Prepared the Interim Pre-design Investigation Report for on-site impacts to optimize the site closure strategy by improving hydraulic containment of on-site groundwater contamination using the existing groundwater extraction and treatment system and completing supplemental source characterization and in-situ remediation to substantially and more cost-effectively reduce mass flux to groundwater, and ultimately advance transition of remediation efforts from active to passive.

Remedial Investigation and Action, Confidential Aerospace Client, Former Aerospace Manufacturing Facility, Long Island, New York

O&M Manager. Directed O&M for two groundwater extraction and treatment systems (800 gpm, 400 gpm) and one SVE system for CVOC remediation in soils and groundwater. Groundwater treatment systems both included redundant air stripping treatment, and one included offgas treatment using vapor phase activated carbon and potassium permanganate zeolite. Upgraded the SVE system process mechanical and off-gas treatment systems to improve performance on a design-build basis. Ramped up the O&M program to improve performance and optimized life-cycle cost through development and implementation of O&M SOPs, including routine and preventative maintenance schedules. Designed and implemented a pilot test for treatment of low-level vinyl chloride to non-detectable concentrations using potassium permanganate zeolite. From 2006 to present, managed development and application of groundwater flow and transport modeling for the Magothy and Lloyd aquifers to support the RI/FS and RD/RA decisions and assist the client with NYSDEC and water purveyor discussions/negotiations.

Groundwater RA Optimization /FFS and RD, Bog Creek Superfund Site, Howell Township, New Jersey

Project Manager. Completed a FFS for a former septic landfill site impacted by CVOCs (chlorinated ethanes and ethenes) and petroleum hydrocarbons in groundwater. The existing P&T remedy with barrier wall and effluent recirculation had been in operation for 10 years, and remedial progress achieved to date was less than predicted in the Record of Decision and desired by project stakeholders. Worked with project stakeholders to update RA objectives and remediation goals for the site. Developed and implemented an expedited schedule that allowed for FFS completion over a five-month period, including associated field investigation, groundwater modeling, and human health risk assessment activities. Optimization alternatives focused on modifying the groundwater extraction system to reducing contaminant travel time to recovery wells, re-designing/upgrading the ex-situ treatment system to reduce associated OM&M costs, and adding in-situ treatment to accelerate residual source mass reduction via physical, chemical, and/or biological processes. Provided technical/administrative support to the EPA and USACE for the associated ROD amendment and supervised SLERA completion for the adjacent brook. Selected for the subsequent design work an managed the project through completion of the intermediate design stage, including completion of pre-design investigation sampling, pumping tests, and in-situ air/bio sparging tests, and development and application of groundwater flow and MVS systems for design application.

Site-wide Groundwater and Soil RA, Tutu Wellfield Superfund Site, St. Thomas, US Virgin Islands

Project/Resident Engineer and Construction Manager. Played a lead role in securing this $5.6M project Win. Responsible for daily technical and administrative management of the project. Prepared the Work Plan and Cost estimate. Prepared technical amendments to the soil and groundwater RD specifications (see RD project descriptions below) to integrate both designs and take advantage of associated economies of scale. Worked intimately with procurement/contracts staff to prepare the Div. 0 specifications for the RFP for RA Services, which included site-specific proposal evaluation criteria and liquidated damages provisions targeted toward the unique location, business environment, and climate associated with this project. Performed technical evaluations of all proposals, and participated in Offeror discussions, negotiations, and final selection. Prepared local permit equivalency applications and coordinated approval with VI DPNR. Serve as the primary point of contact for the project, and maintain relations with EPA, DPNR, and affected property owners. Reviewed all construction shop drawing submittals and coordinated specialty reviews with structural, electrical, and instrumentation design discipline groups. Responsible for overseeing all work performed by RA Construction Subcontractor and resident engineers/inspectors, and ensuring that all construction QA/QC and health and safety requirements are adhered to. Coordinate review and approval of all Subcontractor payment invoices and change orders. Performed resident engineering during treatment system shakedown and initial startup testing, and conducted the Pre-final and Final Inspections. Reviewed as-built drawings, evaluated ITP data, and prepared the ITP Report. Supervised preparation of the Remedial Construction Report and O&M Manual, and supervised O&M and preparation of annual reports.

Site-wide Groundwater RD, Tutu Wellfield Site, St. Thomas, US Virgin Islands

Task Manager and Project Engineer. Supported the site-wide groundwater RD. Completed the RD to hydraulically contain and remediate the target CVOC plume area, which is approximately 3,500 feet in length and situated within a fractured bedrock aquifer. Supervised and assisted in the construction a three-dimensional groundwater flow model for aquifer underlying the site drainage basin, which was used to support design decisions regarding extraction/monitoring well placement, capture zone analyses, and assessments of MNA effectiveness for plume fringe areas. Performed technical evaluations to: assess the effectiveness of MNA versus groundwater extraction and treatment for the downgradient plume area based upon the results of contaminant concentration trend analyses, intrinsic bioremediation analyses, and transport modeling; and assess and screen various innovative technologies (thermally-enhanced extraction, chemical oxidation, enhanced bioremediation) for potential enhancement for the ROD source area remedy (groundwater extraction and treatment) to target the PCE DNAPL source. Prepared the 100% RD Report, Specifications and Drawings, which included the design of: two packaged groundwater treatment plants that utilize air stripping to remove CVOCs from groundwater at/near the plume source; MNA of the downgradient plume fringes; and a pilot study of enhanced anaerobic bioremediation to control the dissolution rate of and to enhance mass removal from the PCE DNAPL source.

Curriculum Center Soils RD, Tutu Wellfield Site, St. Thomas, US Virgin Islands

Project Engineer and Task Manager. Evaluated soil gas data obtained from 10 nested soil gas monitoring wells installed in fractured bedrock within the PCE source area. Prepared the technical SOW and RFP for the SVE pilot study. Supervised field execution of the SVE pilot study, analysis of testing results, and report preparation. Calculated risk-based emissions rates using the EPA Screen 3 model, sized the blower and the activated carbon and potassium permanganate offgas treatment equipment, and presented conclusions and recommendations to EPA according to a range of design scenarios and costs in the Pilot Study Report. Prepared the 100% RD Report, Specifications, and Drawings for the full-scale SVE system.

Pre-Design Investigation, Curriculum Center Soils and Site-Wide Groundwater RD, Tutu Wellfield Site, St. Thomas, US Virgin Islands

Project Engineer. Served the soils pre-design investigation. Provided technical/engineering support to the field investigation team during the pre-design investigation. The investigation scope included delineating: PCE-contaminated soils at a government-owned property; source areas suspected to contain PCE product (DNAPL); and contaminated groundwater (site-wide). Provided technical support associated with SVE and pump tests, and sample location selection. Gave an oral presentation at the Department of Justice (DOJ) in Washington D.C., which summarized the interim findings of the pre-design investigation to DOJ, EPA, Virgin Island government, and PRP attorneys.

RD/RA Oversight, Multiple Sites, New York, Puerto Rico, US Virgin Islands

Project Manager and Project Engineer. Managed numerous RD/RA oversight projects. Coordinated and supervised PRP-lead remedy implementation at the Kentucky Avenue Wellfield Site in Elmira, NY (groundwater P&T, SVE/AS, soil excavation/disposal, sediment dredging for PCBs and heavy metals), the GE Wiring Devices Site in Ponce, Puerto Rico (soil excavation, wet separation, disposal for free and residual mercury), the Tutu Wellfield Site in St. Thomas, USVI (SVE, P&T, in-situ and ex-situ bioremediation for BTEX and CVOC contamination), and others. Worked collaboratively with EPA, PRPs, PRP contractors to facilitate work completion. Provided technical assistance to EPA during public meetings. Assisted EPA with legal strategy development for PRP negotiation and settlement. Prepared Preliminary and Final Closeout Reports. Established a solid reputation within EPA as a strong technical performer, collaborator, and progress facilitator.

Groundwater FFS, Emmell's Septic Landfill, Galloway Township, New Jersey

Project Engineer. Supported a groundwater feasibility study to evaluate remedial options for control and treatment of CVOC plume. The existing plume is over 2,000 feet in length and spans two aquifer zones. The primary contaminants are cis-1,2-DCE and vinyl chloride, both which are present as a result of intrinsic anaerobic biodegradation of TCE at concentrations exceeding 1 ppm. Supervised the operation of a groundwater treatment system during a 72-hour pump test and collected influent, intermediate, and effluent samples/field measurements to evaluate its performance. The treatment system included low-profile air stripping and liquid-phase carbon polishing with vapor-phase carbon and potassium permanganate offgas treatment. Evaluated treatment system performance for CVOC removal, and for TSS/TDS removal and fouling potential related to iron/manganese and hardness. Analyzed the site-wide groundwater quality data for intrinsic biodegradation activity, and the applicability of MNA and enhanced bioremediation as potential remedial options. Demonstrated the occurrence of significant intrinsic anaerobic CVOC biodegradation activity in groundwater using EPA protocol and screening models. Developed the supplemental RI strategy for defining the nature and extent of contamination along the leading edge of the plume, which was determined to extend significantly further and deeper than originally anticipated, through discrete interval groundwater screening and confirmation sampling at select intervals where evidence of contamination is detected. This strategy was accepted by EPA and implemented in the Fall of 2003. Developed two conceptual design alternatives for achieving hydraulic control of the VOC source area in a sand aquifer via groundwater extraction and treatment (150 to 225 gpm capacity). Developed the treatment train, which consisted of bag filtration, sequesterant injection, air stripping, and offgas treatment (carbon followed by potassium permanganate). Completed calculations to estimate remedial pumping rates. Completed air dispersion analyses to evaluate the downwind air quality impacts of air stripper emissions (without treatment) corresponding to various stack heights using the EPA SCREEN3 model. Wrote technical descriptions for FFS design alternatives. Supervised staff in completing all other design calculations, technical and cost analyses, and FFS report sections and figures.

Remedial Design, Multiple Towns, Essex County, New Jersey

Project Engineer. Participated in the design of excavation/disposal remedies for numerous residential properties constructed on radium-contaminated fill materials at the US Radium and Montclair/Glen Ridge Superfund Site.

Groundwater FS, Puchack Wellfield Superfund Site, Camden, New Jersey

Project Engineer. Analyzed the existing groundwater quality data to assess the fate and transport of hexavalent chromium for a plume that is more than 1,000 in length and width, and spans three separate aquifer units. Researched the geochemical mechanisms and properties governing chromium transport, oxidation/reduction, and precipitation. Estimated site-specific Kd values/relations for chromium using soil and groundwater data and compared estimates to literature values. Performed chromium migration rate estimates using the retardation equation, considering Kd estimates corresponding to the center and leading edge of the plume. Estimated total chemical decay rates (assuming first -order exponential decay) for chromium using groundwater concentration time history data at multiple well locations and compared them to literature values. Completed a two-dimensional, plume centerline modeling study to assess the current dynamic state of the plume and to project the downgradient point of compliance, conservatively assuming infinite source and steady-state conditions. Prepared a technical proposal to perform a pilot study for evaluating the feasibility of in-situ reduction and precipitation of chromium. Prepared a treatability work plan, which included bench- and pilot-scale tests to evaluate the feasibility of using in-situ fixation to remediate hexavalent chromium groundwater contamination. Evaluation of various chemical and biological reduction processes was included as part of bench testing.

Municipal Planning, City of Garfield, Garfield, New Jersey

Assistant City Engineer. Assisted the City in pursuing and obtaining various grants and low-interested loans for water meter replacement, water tank rehabilitation, sidewalk and roadway improvements, and recreational facility improvements. Prepared corresponding bid documents and coordinate construction QA inspections. Attended Mayor and Council meetings, and worked directly with the CFO to support related financial planning and grant/loan/application efforts. Assisted with evaluation of options to reactive City wells that were closed due to VOC and hexavalent chromium contamination.

Infrastructure assessment, Greystone Park Psychiatric Hospital, Morris Plains, New York

Project Engineer. Acted as part of team of architectural and engineering firms with the goal of identifying recommendations for redevelopment of smaller, updated hospital facility. Assessment scope focused on current and future potential land use, environmental issues, storm and sanitary sewer systems, potable water and fire supply systems, sewage treatment plant, and utilities.

Brookhaven National Labs, Brookhaven, New York

Project Engineer. Participated in the design of capping and storm water drainage/recharge systems for three landfills, excavation/disposal of a large disposal pits area containing waste drums and bottles, and a groundwater extraction and treatment system. Applications involved various chemical and low-level radiological contaminants. Performed risk assessment modeling for residual radionuclide impacts using DOE’s RESRAD model. Worked with groundwater modelers to calculate site-specific, leach-based soil cleanup goals using soil/water partitioning and site-specific dilution-attenuation factor calculations. Performed related Feasibility Study assessments to evaluate design alternatives, and provided shop drawing submittal review support during construction.

Kentucky Avenue Wellfield Superfund Site, Elmira, New York

Resident Engineer. Performed resident engineering and construction QA inspections during construction of two large-scale groundwater extraction and treatment facilities for hydraulic containment of VOC impacts.

O&M Services, Lipari Landfill Superfund Site, Mantua, New Jersey

Project Engineer. Provided routine O&M services for a hydraulic containment and batch flushing system consisting of a low-permeable cap and slurry wall, and a groundwater extraction, treatment, and recirculation system. Evaluated remediation process and monitoring well data to assess remedial performance based on hydraulic containment and contaminant mass reduction. Prepared annual O&M reports and identified recommendations for performance optimization/improvement. Assisted with fate-and-transport assessments for the off-site VOC/SVOC plume and design of a seep collection trench system.

Construction Services, EPA Regions 2 and 4

Construction Manager. Construction QA inspections and participated in initial startup verification testing programs at numerous Superfund sites involving implementation of excavation/disposal, caps and barrier walls, groundwater extraction and treatment, and soil vapor extraction remedies in.

Other

- RCRA Facility Assessments across New York State for EPA Region 2.
- Resident engineering, construction inspections, and confirmatory air sampling for large-scale asbestos abatement projects in New York City for the NYCDEP and private clients.
- Resident engineering and construction QA inspections for a remediation project in Nashua, New Hampshire involving landfill capping, soil vapor extraction, and waste excavation/disposal.

Memberships

New Jersey Water Environment Federation (NJWEA)

Borough of Oakland - Recreation Commission, Environmental Commission

Experience Summary

Frank Williams is a Supervising Geologist with 31 years of varied experience in hydrogeology and petroleum geology, hazardous site investigation and remediation, RI/FS and complex environmental site evaluation, including 20 years of project management.

Mr. Williams has supervised the investigation and remediation to closure of industrial waste disposal sites and bulk petroleum storage facilities. He has extensive experience with the NYSDEC Hazardous Waste Remediation, Petroleum Spills and Voluntary Cleanup/Brownfields programs at diverse sites, including former manufactured gas plants, chlorinated solvent spills, chemical waste lagoons, marine terminals, and waste recycling facilities. Mr. Williams also has extensive experience with non-aqueous phase liquids, including DNAPL-impacted soils and bedrock.

Mr. Williams has experience in all phases of developing large, comprehensive environmental databases and reconstructing early industrial site conditions. He has provided scientific support for a variety of environmental litigation efforts, including the defense of the Love Canal landfill cases. Mr. Williams has provided expert testimony at trials in Federal Court.

Assignment

PDI Technical Lead

Education

A.B., Geology, Princeton University, 1978

Registrations

Professional Geologist, Pennsylvania, PG-02643-G, 1995

Professional Geologist, New Hampshire, PG-656, 2003

Training

OSHA Hazardous Site Training 40-hrs

DOT Hazardous Materials Training

Experience

31 years

Joined Firm

2003

Relevant Expertise

- *NYSDEC Voluntary/Brownfields Cleanup Program*
- *NYSDEC RI/FS and site remediation programs*
- *DNAPL/LNAPL transport and fate*
- *Remediation of petroleum spills*
- *Complex site litigation support*

Hazardous Waste Site Characterization and Remediation

Mercury Refining Superfund Site, Pre-Design Investigation, Colonie, New York

Project Manager Mr. Williams managed a pre-design investigation conducted on behalf of a number of PRPs who had sent mercury-containing materials to this former retorting facility for recycling. An earlier remedial investigation (RI) conducted by the USEPA confirmed the presence of mercury impacts in soil, groundwater and stream sediments, but left significant data gaps with respect to the volume and extent of impacted media. Before committing to remediation of the site, the PRPs desired more clarity of scope and cost. A Remedial Design Work Plan (RDWP) was developed, and included field investigations to delineate impacted media. Soil contamination was delineated using a closely spaced sampling grid spanning several adjoining properties. Characterization of groundwater required special attention. The ROD called for *in situ* solidification/stabilization (ISS) of saturated soils wherever the concentration of dissolved mercury exceeded the groundwater standard 0.7 ug/L. Groundwater sampling conducted during the RI exaggerated the extent of the dissolved mercury "plume" because it employed direct-push equipment that produced excessively turbid groundwater samples. The pre-design investigation more accurately delineated the true, three-dimensional extent of the 0.7 ug/L limit by employing closely spaced nests of monitoring wells. Extraordinary well construction measures (e.g., drive-and-wash casing, double sand packs) were employed to ensure the wells would provide groundwater samples that were free of suspended solids and therefore representative of the dissolved mercury criterion for ISS.

The pre-design investigation results, including visual observation of metallic mercury and mercury vapor readings, indicated that most mercury impacts at the site were in the metallic form (i.e., elemental mercury). This was further supported by the groundwater data which indicate limited dissolved phase mercury concentrations, suggesting that mercury at was either in the insoluble metallic form or in ionic forms that are part of low solubility compounds.

Pesticide-Impacted Site on Long Island, Confidential Client, New York

Project Manager. Remedial Investigation and IRM of a site located in an urban, mixed-use neighborhood of commercial and industrial facilities and residences. Beginning in the mid 1950s, pesticides and herbicides were used and stored on-site. Soil and groundwater at the site have been found to be contaminated with pesticides and herbicides. Groundwater samples also contained the chlorinated solvents tetrachloroethene (PCE), trichloroethene (TCE), and cis and trans 1,2 dichloroethene (DCE). A soil vapor intrusion (SVI) study was performed to assess potential exposure of site workers to the off-site chlorinated solvents. As part of the RI, the existence of potential leaching structures (drywells) and an underground storage tank (fuel oil UST) were evaluated using electromagnetic (EM) induction and ground penetrating radar (GPR) techniques. A drywell/septic system impacted with pesticides was remediated and closed under an IRM. Community air monitoring was performed during all RI and IRM field activities in accordance with the New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan. Brown and Caldwell prepared a citizen participation plan (CCP) to keep the public informed of planned or ongoing actions; environmental conditions; public health threats (if any) posed by contamination and responses under consideration; and project status. Preparation of "fact sheets" or "public information session announcements", public meetings, and a document repository are part of this CCP.

BB&S Treated Lumber Site, NYSDEC, Suffolk County, New York

Project Manager. Pre-Design Investigation of a former CCA pressure treating facility located on Long Island. Chromium, copper and arsenic impacts were delineated in shallow and deep soils and in groundwater. Overland flow of spilled CCA solutions required delineation of extensive off-site impacts to shallow soil extending through adjacent forested areas. Vertical groundwater profiling was used to evaluate alternatives for in-situ control of metals migration in groundwater. Source areas were characterized under and adjacent to the pressure treating operations building. Assisted NYSDEC in contacting neighbors and facilitating off-site delineation of chromium plume.

Apple Valley Shopping Center Site, NYSDEC, LaGrange, New York

Project Manager. RI/FS of chlorinated solvent impacts in overburden and bedrock resulting from past releases of dry cleaning fluids. Provided assessment of data gaps in earlier investigations, developed work plan to investigate source areas and identify discrete migration pathways in bedrock. Identified contaminant pathways in bedrock aquifer by caliper and temperature logging of existing production wells, coring of monitoring wells, and packer testing of discreet transmissive features. Conducted Feasibility Study of remedial alternatives, including source-area remediation through dual-phase extraction, injection of chemical oxidants, and management of bedrock PCE plume.

Farrell Property Site, NYSDEC, East Nassau, New York

Project Manager. RI/FS of tar- and petroleum-based wood preservative impacts caused by migration from treatment pits through glacial outwash and fluvial gravels. Focused on shallow and deep groundwater, soils, wetlands, and a DEC-designated trout stream. Conducted Fish and Wildlife Impact Assessment (FWIA) and qualitative human health exposure assessment. Feasibility Study evaluated source removal and containment alternatives for tarry residues.

Yonkers Raceway, Yonkers, New York

Project Manager. Comprehensive environmental services in support of potential site divestiture or development scenarios for this 100 year-old harness racing track. Closed six large underground petroleum and waste oil storage tanks, obtaining NFA status from regulatory agencies for all tanks. Conducted comprehensive investigation of extensive storm and sanitary sewer systems, including effluent and sediment characterization. Sampled numerous indoor and outdoor electrical transformers and substations to determine regulatory status with respect to PCB content. Managed pre demolition survey of potential hazardous wastes. Managed site-wide asbestos survey, design and abatement program in support of casino development.

Port of Rensselaer Marine Terminal, Chevron Products Corporation, Rensselaer, New York

Project Manager. Comprehensive remedial design study and IRM. Delineated LNAPL distribution and migration in tidally influenced zone throughout facility. Supervised offshore sediment assessment and contaminant transport study to evaluate potential impacts by dissolved contaminants originating in on-shore source areas. Negotiated scope of work and schedule of compliance for Stipulation Agreement between client and NYSDEC. Supervised product removal activities using HiVac™ centrifugal pump and OilMop™ lipophyllic belt systems.

New York State Brownfields

Former Photo Processing Facility, Jostens Inc., Webster, New York

Project Manager. Investigation and remediation to closure under NYSDEC Voluntary Cleanup Program. Delineated nature and extent of inorganic and organic photo processing wastes associated with former wastewater lagoons and transfer lines operated by a previous owner. Developed comprehensive assessment of soil, sediment, surface water, air and groundwater (bedrock and overburden) migration pathways. Conducted FWIA and human health exposure assessments that ruled-out most exposure pathways. Remediated interior concrete surfaces and soil gas infiltration pathways. Negotiated with NYSDEC a final site remedy that consisted of development of a soil management plan and institutional controls.

Former Scrap Yard Site, Nashua Corporation, Watervliet, New York

Project Manager. Investigation and remediation to closure of a listed Class 2 site under NYSDEC Voluntary Cleanup Program. Delineated and remediated PCB contamination attributed to a former site occupant that salvaged electrical transformers and possibly aircraft hydraulic systems. Developed soil sampling and management plan to facilitate emergency sewer construction through PCB contaminated soils. Managed investigation of soil and groundwater to characterize nature and extent of PCBs, metals and VOCs. Negotiated Remedial Work Plan with NYSDEC and NYSDOH and addressed issues raised during public participation. Managed remedial design and engineering oversight of remedial construction.

Carousel Center Redevelopment, Oil City, Pyramid Development Corporation, Syracuse, New York

Operations Manager. Part of site remediation management team for one of New York's first Brownfields redevelopment projects. Responsible for coordinating 24-hour, seven days per week remediation activities involving more than 30 on-site environmental specialists. Project team provided comprehensive environmental monitoring and soil characterization services during remediation of soil and groundwater impacted by hazardous wastes and petroleum products.

Manufactured Gas Plants

Gastown MGP Site, NYSDEC, Tonawanda, New York

Project Manager. Remedial Investigation of an MGP site situated in a residential neighborhood on the Tonawanda Creek. Directed the preliminary excavation and mapping of relict gas and tar handling structures and apparatus. Defined the extent of DNAPL and impacted groundwater migrating beyond the Site in glacial/fluvial sands and gravel and creek sediment. Conducted extensive sampling and analysis (Method TO-15) of residential sub-slab soil gas to evaluate potential VOC infiltration. Conducted pilot test of innovative, proprietary pressure-pulse technology to facilitate mobilization of residual coal tar through fine alluvial sediments.

NIMO Troy - Water Street MGP Site, National Grid, Troy, New York

Project Manager. Pre-Design and Hydrogeologic investigations of a 16 acre site located along the Hudson River that was utilized for the production of iron, coke, water gas and associated byproducts, including various distillates and asphalt products. The site was later operated as a major oil storage facility and marine terminal for the distribution of petroleum products. The investigations support a remedial design for the removal of impacted soils, NAPL recovery, in-situ chemical oxidation (ISCO), monitored natural attenuation (MNA), and institutional controls. The investigations include bench-scale and field pilot testing of ISCO technologies. An extensive soil boring and test pitting effort delineated subsurface structures and wastes, including LNAPLs and DNAPLs, and provided three-dimensional resolution of deep alluvial sediments targeted for ISCO. Intact soil samples were collected for bench-scale testing to determine optimal ISCO parameters for both MGP and petroleum-derived wastes. The Fenton's Reagent ISCO process was pilot tested in a portion of the site impacted with coal tar and petroleum residues, including BTEX and PAHs. Soil gas sampling with Summa canisters was conducted to identify the presence of VOCs with a potential to infiltrate on-site structures.

Cohoes Linden Street MGP, National Grid, Cohoes, New York

Project Manager. Remedial Investigation of a former MGP located near the confluence of the Hudson and Mohawk rivers. The investigation characterized the extent of MGP impacts in a complex bedrock environment by utilizing rock coring, packer testing and down-hole geophysical logging. The potential flux of MGP constituents to the river environment was evaluated by measurement of river discharge rates and by continuous data logging of groundwater and surface water elevations. This evaluation, together with sediment and surface water analyses, supports the assessment of potential risks to ecological resources through a Fish and Wildlife Impact Assessment. Potential vapor intrusion of site-related structures was evaluated through collection and analysis of soil gas samples.

Rensselaer MGP, National Grid, Rensselaer, New York

Project Manager. Site Characterization, IRM Evaluation and RI of an MGP site located in a mixed use, urban setting. Field investigation conducted outside of normal business hours to avoid conflicts with current use of the site. Site conditions were evaluated through test pitting, soil borings, monitoring wells, and soil and groundwater sampling and analysis. An RI is currently being conducted to further characterize MGP impacts identified during the SC. Sampling of groundwater, sediments and soils on adjacent commercial and residential properties is being conducted. Prepared fact sheets and citizen participation plan (CPP) for informing public of ongoing activities and findings.

Mohawk MGP, National Grid, Mohawk, New York

Project Manager. Site Characterization and IRM Evaluation of an MGP site located in a mixed use, urban setting. Site conditions were evaluated through test pitting, soil borings, monitoring wells, and soil and groundwater sampling and analysis. Based on the results of the SC/IRM, NYSDEC determined that no significant impacts were present and required no additional characterization.

Penske Truck Leasing, Former MGP, Tarrytown, New York

Project Geologist. Conducted preliminary investigation of groundwater and soil contamination at the site of a trucking terminal and former MGP. Groundwater and soils at site were contaminated with residues from petroleum fuel spills and manufactured gas wastes. Reviewed the available history of site operations, the limited database of chemical analytical results, and sampled dense non-aqueous phase liquids from monitoring wells. Evaluated the efficacy of the existing groundwater recovery system in remediating two-phase contamination.

Former MGP, Confidential Client, Middletown, New York

Project Manager. Preliminary Investigation of former MGP site. Retained by site owner to investigate source of tarry wastes and VOC vapors at commercial retail facility. Confirmed the presence of MGP wastes and their impact on soil gas underlying the facility.

Decommissioning and Demolition

Nashua Tape Products Facility, New York

Project Manager. Mr. Williams managed the decommissioning of the former Nashua Tape Products factory in Watervliet, New York. The one million square-foot facility produced tape products with both cold-compound and solvent-based adhesives. Solvent-based adhesives were removed from mixing vessels and associated piping. Asbestos was abated on tape drying ovens that were several hundred feet long. Much of the factory floor was scarified to remove accumulated adhesive residues. The decommissioning included the decontamination and dismantling of a three story paper coater that employed several thousand gallons of PCB-based heat transfer fluid (Therminol) for drying the release coat on masking tape paper. Piping and hot oil rollers were drained of Therminol and disposed of as TSCA regulated waste. The coater superstructure was decontaminated and recycled as unregulated scrap steel. Wipe sampling was used to verify that TSCA cleanup criteria had been met. Analysis of core samples taken from of the concrete floor showed that PCB's had diffused several centimeters into the concrete and that scarification of the floor would not be cost-effective compared to complete demolition and removal. Air monitoring was conducted during the entire dismantling effort to verify that PCB vapors and particulates did not exceed applicable health and safety standards.

National Grid, Pre-Demolition Characterization and Demolition of Various Structures, Upstate New York

Project Manager. Pre-demolition studies were required for a number of inactive industrial and commercial facilities used in power transmission and maintenance. Potentially regulated materials were identified through visual inspection with follow-up sampling to confirm and delineate these materials. Involved sampling many building materials and analysis for PCBs, lead, asbestos and other hazardous substances.

Expert Testimony and Litigation Support

Occidental Chemical Corporation, Love Canal Defense, New York

Project Manager, Expert Witness. Multidisciplinary support for the successful defense of punitive damages and CERCLA liability claims brought by governments in Federal Court. Coordinated the efforts of experts in aerial photographic interpretation, photogrammetry, computer modeling of soil mechanics, hydraulics and chemical transport modeling.

Developed comprehensive evaluation of more than a decade of environmental study by various government agencies. Constructed flow charts and time-lines to examine the relationship between governmental agency activity and the availability of technical information upon which administrative decisions (e.g. the Emergency Declaration) were made. Reconstructed information from significant portions of multi-million-page document production by various government agencies.

Compiled evidence of third-party contribution to contaminant releases by investigating 19th and 20th century archival documentation of canal construction and development. Reconstructed early conditions of state-constructed sewer system and developed evidence enabling OCC to prove that the state's sewer accelerated migration of Love Canal wastes by a factor of 30,000. Resolved key issues of historical DNAPL distribution and waste burial in the Love Canal area.

Developed GIS to facilitate graphic data evaluation and identification of spatial and temporal patterns in 500,000 record analytical database. System also integrated hydrogeologic data, sequential residential development and evolution of drainage features.

Tape Manufacturer, RCRA Corrective Action Litigation Support, Solvent Contamination, Confidential Client

Project Manager and Expert Witness. Investigated 90-year-old tape manufacturing facility impacted by a massive release of toluene and heptane. Directed sampling and analysis of soil, groundwater and sewer media. Evaluated voluminous historical information concerning plant operations, waste streams and potential chemical releases. Conducted preliminary evaluation of potential relationship between sewer infiltration and water table fluctuation using contemporaneous data logging of sewer flow rates and groundwater elevations. Developed preliminary assessment of SWMUs/AOCs as part of RCRA facility assessment. Negotiated SWMU inventory based on review of historical documentation of plant design and operation. Negotiated work plan with NYSDEC to develop and pilot test an Interim Remedial Measure. Testified at trial in CERCLA cost recovery litigation against former owner. Addressed issues of solvent origins, migration and persistence in the environment and NCP consistency of client's response actions.

Remediation/Litigation Support PCB Contaminated Waste Oil, Confidential Client

Project Manager, Expert Witness. Investigated waste oil processing facility contaminated by PCB wastes. Developed and implemented sampling and analysis plans to characterize multiple phases of contaminated materials in facility's tanks and circulating system. Supervised preliminary subsurface investigation to characterize nature and extent of gasoline/fuel oil contamination in groundwater. Developed work plan for subsurface remediation and decontamination of facility. Expert witness in cost recovery litigation. Testified at trial on chemical characteristics and probable sources of contamination.

Chevron Texaco, Harbor Point MGP, Asphalt Emulsion and Petroleum Bulk Storage Sites, Utica, New York

Project Manager, Expert Witness. Litigation consultant in dispute over liability and cost allocation between multiple PRPs for a former manufactured gas site. Provided hydrogeologic and remediation consulting services to one of several PRPs for NYSDEC-mandated site remediation. Evaluated complex, multi-source impacts by historic MGP operations, asphalt manufacturing, petroleum bulk storage, and organic chemical warehousing and distribution. Synthesized subsurface data from decade-long history of investigations to define three-dimensional distribution of coal tar, asphalt and petroleum impacts in multiple hydrogeologic units. Provided chemical-analytical assessment of impacts by complex mixtures of volatile aromatic and PAH compounds derived from coal tars, asphalts and petroleum products. Compared the frequency distribution of petrogenic and pyrogenic polycyclic aromatic hydrocarbon (PAH) species. Assessed remediation strategies, provided critical review of and commentary on NYSDEC's Proposed Remedial Action Plan.

Litigation Support of Landfill Closure Cost Recovery, Confidential Client

Project Manager, Expert Witness. Provided expert assistance to municipality seeking recovery of landfill closure costs from generators and transporters. Evaluated diverse evidence of specific industrial wastes, including documentation of wastes uncovered during landfill consolidation and capping, pre-closure groundwater monitoring, and records of waste production produced by litigants. Researched production technologies to identify CERCLA hazardous substances found in generator's waste streams. Provided documentation of quantity and nature of drummed industrial waste.

Deposition and Trial Testimony, Various Clients and Locations

- United States of America et. al. vs. Hooker Chemicals & Plastics Corporation, et al.; United States District Court, Western District of New York; 79 CV 990C (Love Canal Landfill); 1990 1991 (trial).
- Nashua Corporation vs. Norton Company; United States District Court, Northern District of New York; 90 CV 1 3 5 1; 1995 1996; (trial).
- The Town of New Windsor vs. Tesa Tuck, Inc., et al.; United States District Court, Southern District of New York; 92 CV 8754; 1995 (deposition).
- Occidental Chemical Corp., et al. vs. Hartford Accident and Indemnity Co., et al.; Supreme Court of the State of New York, County of Niagara; Index No. 41009/80; 1996 (deposition).
- B.C.F. Oil Refining, Inc. vs. Consolidated Edison Company of New York, et al., United States District Court, Southern District of New York; 94-CV-8499; 1997 (trial).
- Niagara Mohawk Power Corporation vs. Texaco Inc. et al., United States District Court, Northern District of New York; 95-CV-717; (Harbor Point Site) 1999 (deposition).

Memberships

Sigma Xi

Hudson Mohawk Professional Geologists Association

National Water Well Association (Association of Groundwater Scientists and Engineers)

Publications

Shaw, G., F.J. Williams, P. Gremillion, "Stream Tracing In The Bogardus Spring System, Schoharie County, New York", GSA Abstracts with Programs Vol. 36, No. 5, November 2004.

Marek Ostrowski, PE

Experience Summary

Marek Ostrowski is a Senior Environmental Engineer/Geohydrologist working as a technical lead on environmental projects. Mr. Ostrowski develops scope of work documents and level of effort estimates. He develops plans for field investigations; analyzes data obtained by field personnel; develops conceptual site models; performs numerical and analytical modeling; investigates impact of contamination on human and environmental receptors; develops remedial strategies and evaluates remedial methods/technologies; designs environmental remediation systems; analyzes system performance; presents findings to clients and regulating agencies; develops Design Drawings, as well as reports, such as Work Plans, Remedial Investigation Reports, Feasibility Study Reports, Alternative Analysis Reports, Remedial Action Selection Reports, Data Analysis and Design Analysis Reports. Mr. Ostrowski coordinates work of various disciplines involved in completion of projects; he supervises and mentors junior staff.

Areas of expertise include: hydrologic/hydrogeologic investigations, environmental modeling, exposure assessment, landfill and drainage design, dewatering, underground storage tanks remediation, hazardous waste remediation, water supply, sanitary and storm sewers. Major work in the field of environmental remediation: ground water extraction and treatment, excavation of contaminated soil/sediments, dewatering, soil vapor extraction, sub-slab depressurization, air sparging, product recovery, in-situ bioremediation, constructed wetlands, landfill leachate handling, monitored natural attenuation.

Worked on projects for the following major clients: chemical industry, energy industry, PRP groups, US Air Force, US Department of Energy, US Army Corps of Engineers, US Environmental Protection Agency, NYS Department of Environmental Conservation, NYC Transit, NYC Department of Design and Construction, New York City School Construction Authority, local governments, landfill operators.

Assignment

SVE/SSDS Design Engineer

Education

M.S., Civil Engineering, State University of New York at Buffalo

B.S., Civil Engineering, State University of New York at Buffalo

Registrations

Professional Engineer, New York 1996
Professional Engineer, New Jersey 2009

Professional Engineer, Delaware 2010

Experience

24 Years

Joined Firm

2009

Former Manufactured Gas Plants

National Grid Former Manufactured Gas Plant Sites: Watertown Engine St, Oswego West Utica St, Village of Patchogue, Cohoes Linden St, New York

Engineer. Feasibility Studies and Remedial Designs at several National Grid former MGP sites. Developed Feasibility Study and Alternative Analysis Reports. Developed elements of Design Reports, including report text, project plans, treatability studies for in-situ solidification/stabilization, cost estimates and drawings. Supervised, coordinated and reviewed work of junior staff.

New York State Electric and Gas Cortland/Homer, Saranac Street, Court Street, Mechanicsville and Transit Street Former Manufactured Gas Plant Sites, New York

Lead Engineer and Geohydrologist. Remedial Investigation/ Feasibility Studies and Remedial Action Designs at several NYSEG former MGP sites. Investigation included hydrogeologic site assessment, identification of nature and extent of contamination, development of conceptual site models, aquifer testing, modeling of groundwater flow and contaminant migration, and modeling of groundwater extraction. The designs included open and sheeted excavation of contaminated soils, coal tar and river sediments; disposal of the excavated materials, excavation dewatering and treatment of the extracted groundwater, river flow diversion, NAPL recovery, in-situ solidification of the on-site soils, vertical barriers and site/river restoration. Responsible for the preparation of the Remedial Design Work Plans, including coordination of work between various disciplines, supervision of junior staff and interaction with client.

KeySpan Hempstead Intersection Street Former MGP Site, Hempstead, New York

Lead Geohydrologist. Feasibility Study and Interim Remedial Measure design for a large MGP site in Long Island, New York. Coordinated a site-wide groundwater monitoring and sampling program. Developed and evaluated remedial alternatives, including hydraulic containment, vertical barriers, in-situ treatment and excavation. Solicited bids from contractors. Also responsible for siting and designing of DNAPL recovery wells. Responsible for coordination of work between disciplines and presentation of findings to the client.

Air Force Bases

Loring AFB, Massachusetts, Pease AFB, New Hampshire

Lead Engineer. Led the design of two large air sparging/soil vapor extraction remediation systems at sites contaminated with petroleum product and solvents. Analyzed existing environmental data bases. Developed conceptual site models and analyzed design alternatives. Designed and interpreted air sparging pilot tests. Designed the air sparging/soil vapor extraction systems. Responsible for preparation of design drawings and coordination of work between various disciplines.

Plattsburgh Air Force Base, New York

Lead Engineer and Geohydrologist. Served a large project involving remediation of numerous sites at the Plattsburgh AFB in Plattsburgh, New York. The project included the development of a numerical groundwater flow model and contaminant transport model to design the optimum system intended to contain a large plume of dissolved contaminants. Compiled results of numerous hydrogeologic investigations at the site. Constructed a conceptual model of the regional hydrogeologic system. Analyzed numerous data from slug tests, aquifer pumping tests, grain size analyses and flow measurement. Used analytical methods to conduct the preliminary analysis of the site. Used USGS MODFLOW code to construct a base-wide regional numerical groundwater flow model. The model involved the interaction between the aquifer and numerous surface water bodies (rivers, a large lake, streams and leaky storm sewers). Calibrated the model to the existing conditions with respect to hydraulic heads and water balance. Participated in the design of the data acquisition program aimed at defining the distribution of contaminants in the aquifer. The program included analyses of data describing attenuation processes taking place in the aquifer. Interpreted an extensive data base of results of water quality sampling (both ground and surface water). Evaluated issues related to the natural attenuation of dissolved hydrocarbons in ground water (product dissolution, adsorption of contaminants, evidence of microbial activity, decay rates). Using an MT3D code developed a numerical model of the groundwater quality in the study area. Calibrated the model to the observed distribution of contaminants. Used the flow and transport model to predict the future behavior of the plume under a variety of scenarios (natural attenuation, extraction of ground water, artificial flushing of the aquifer). Estimated loadings of contaminants into onsite surface water bodies. Used the results to investigate the effect of the discharge of contaminated ground water on the quality of surface water and air. Performed design and cost estimates of ground water remediation systems consisting of an extraction well field and several thousand feet of groundwater collection trenches. Assisted client during the installation of these remediation systems. Designed several remediation systems for peripheral sites located within the base boundaries, including groundwater extraction, soil vapor extraction, product recovery and reinjection. Presented findings to the client and to the public.

Loring Air Force Base, Massachusetts

Lead Geohydrologist. Groundwater modeler for a project involving the operation of a 30-gpm groundwater and product capture system in a bedrock aquifer.

F. E. Warren, AFB, Landfill No. 6, New York

Design Engineer. Participated in the design of the evapotranspiration cap for landfill closure.

Air Force Plant No. 4, Fort Worth, Texas

Lead Geohydrologist. Geohydrologist for a performance assessment of the zero-valent iron permeable reactive barrier (PRB), prepared for the United States Army Corps of Engineers. The study included the review of the long-term monitoring data from the base, groundwater sampling of the PRB transect wells, piezometer installation at the PRB, as well as the review of data and development of recommendations for the future operation of the PRB. Responsible for the analysis of the hydraulic performance of the barrier.

USACE Habitat Restoration

Rochester Harbor, New York

Project Engineer. Served a Habitat Restoration Study at the Rochester Harbor site on Lake Ontario, Rochester, NY. Prepared and conducted field investigation studies to determine the source of algae problem at a public beach, including pilot studies and wind/current measurements. Coordinated hydrodynamic modeling studies performed by a subcontractor. Prepared a Habitat Restoration Study Report. Presented results to the stakeholders, including the city of Rochester and USACE.

Landfills

Pennsylvania and Fountain Avenue Landfills, New York

Lead Geohydrologist and Project Engineer. Groundwater modeler and project engineer for the RI/FSs at two landfills adjacent to Jamaica Bay. Performed detailed three-dimensional groundwater flow modeling using MODFLOW/MT3D, given complex stratigraphy, flow pattern, tidal effects, and boundary conditions. Performed design of remedial systems for contaminated ground water and for product recovery. Designed landfill cap drainage layer. Presented findings to the regulating agencies.

Farmersville Landfill, New York

Design Engineer and Groundwater Modeler. Responsible for the proposed 250-acre solid waste disposal facility. Constructed a numerical ground water flow model of a fractured bedrock and overburden aquifer system. Used the flow model to investigate the short- and long-term influence of the facility on the ground water flow regime. The investigation included the design of permanent dewatering systems for the landfill subgrade and a leachate tank farm, located up to approximately 25 feet below the high ground water table. Estimated construction dewatering volumes to assess the impact of the facility on the nearby surface water bodies. Performed water quality analysis for a trout stream and an impoundment located downgradient of the proposed facility. Designed the cap drainage system. Coordinated work between disciplines and presented findings to the client and regulating agencies.

Fort Edward Landfill, New York

Lead Geohydrologist and Design Engineer. Groundwater modeler and design engineer responsible for groundwater flow modeling and remedial design for the landfill closure. Designed hydrogeologic investigation and constructed a numerical ground water flow model of the site. Used the model to analyze remedial alternatives. Performed design of the constructed wetland treatment system for the treatment of landfill leachate. Coordinated work of various disciplines.

Lipari Landfill, New Jersey

Lead Engineer and Geohydrologist. Responsible for the hydrogeologic aspects of a landfill/stream remediation project. Evaluated aquifer tests and constructed an analytical hydrogeologic model of the site. Used the model to evaluate issues related to the construction of the remedial measure, such as contaminant migration, hydraulic containment, and excavation dewatering. Designed a pore water pressure relief system for the stream dredging and backfill.

DuPont Corporation

Lead Geohydrologist and Design Engineer. Responsible for performing groundwater flow modeling, hydrology and drainage design for the remediation of several landfills.

Ellery Landfill, New York

Design Engineer. Performed quantities calculations and cost estimates. Analyzed and processed field tests data. Performed leachate generation and management studies. Designed elements of leachate collection system and developed its specifications.

CID Landfill, New York

Civil Engineer. Responsible for resolution of issues of sediment control. Performed wetland replacement study.

Lockport City Landfill, New York

Design Engineer. Designed landfill grade for the closure purposes. Designed the stormwater management system. Performed fugitive dust analysis. Performed quality takeoffs and cost estimates.

Dunlop Landfill, New York

Civil Engineer. Performed leachate generation and infiltration analysis. Designed stormwater management system.

Helen Kramer Landfill, New Jersey

Design Engineer and Groundwater Modeler. Responsible for the Helen Kramer Landfill Superfund Remedial Design project. Performed hydraulic calculations of a stormwater management system for a 60-acre site in New Jersey. Responsible for writing specifications and developing cost estimates. Performed groundwater modeling and analysis of remedial alternatives.

Global Landfill, New Jersey

Geohydrologist. Responsible for performing groundwater modeling. Developed and evaluation of remedial alternatives for the Feasibility Study report. Designed groundwater extraction system. Performed effluent limitation study.

Weston Mills Landfill, New York

Groundwater Modeler. Modeled the Weston Mills Landfill RI/FS in Olean, New York, within the flood plain of the Allegheny River. Used the USGS MODFLOW groundwater flow model and SUTRA, a widely used two dimensional transport model, to simulate existing conditions and the areal extent of contaminant migration due to changes in river levels. Also analyzed and processed field data (conductivity tests, stream discharge, etc.) and performed air quality modeling for the risk assessment.

Dura Avenue Landfill, Ohio

Design Engineer and Groundwater Modeler. Remediation project at a 70-acre hazardous waste site in Toledo, Ohio. Used a numerical groundwater flow model to design the optimum capture system for contaminated groundwater. Designed a free product interceptor trench.

Ramapo Landfill RI/FS, New York

Design Engineer and Geohydrologist. Responsible for remedial design and performing groundwater modeling. Designed, performed and evaluated several aquifer pumping tests. Developed and evaluated remedial alternatives for the Feasibility Study report. Designed the interception system for contaminated groundwater. Analyzed slope stability issues. Designed landfill cap.

Underground Storage Tanks

NYCT Underground Storage Tank Project, New York

Lead Engineer and Geohydrologist. Responsible for hydrogeologic investigations, groundwater and free product flow modeling, contaminant transport modeling, and remedial design at several large underground petroleum storage tank projects in New York City. Analyzed various aspects of the soil and ground water contamination by petroleum products, including the com-mingling of plumes from different sources. Designed field investigation programs, analyzed field data (baildown test, high-vacuum recovery tests, air permeability tests, etc.). Performed design of free product recovery systems. Used analytical and numerical models (BIOSLURP) to analyze effects of product recovery alternatives. Evaluated the interaction between an existing free product recovery system and the proposed large-scale well field, which would significantly impact the regional flow regime. Prepared Design Analysis Reports. Analyzed system performance data and recommended system modifications. Responsible for coordination of work between the disciplines. Presented findings to the client and provided litigation support.

NYCDDC Underground Storage Tanks Project, New York

Design Engineer and Geohydrologist. Responsible for hydrogeologic investigations, groundwater and free product flow modeling, contaminant transport modeling, and remedial design at dozens of small to medium underground petroleum storage tank projects in New York City. Analyzed various aspects of the soil and ground water contamination by petroleum products. Designed field investigation programs, analyzed field data (baildown test, high-vacuum recovery tests, air permeability tests, etc.). Performed design of product recovery systems, ground water capture systems and soil vapor extraction systems, as well as in-situ remediation (bioremediation, oxygen injection). Used analytical models to analyze effects of product recovery alternatives. Prepared Design Analysis Reports. Analyzed system performance data and recommended system modifications. Responsible for coordination of work between disciplines.

NJDEP Underground Storage Tanks Project, New York

Geohydrologist and Design Engineer. Responsible for groundwater flow and contaminant transport modeling, hydrogeologic investigations, non-aqueous phase liquid modeling, design of remediation systems – ground water extraction, product extraction, soil vapor extraction systems for the remediation of underground storage tanks. Also assisted in the preparation of Design Analysis Reports.

New York City School Construction Authority, New York

Project Engineer. Responsible for several underground storage tank investigation and remediation projects at the sites of public schools located in the City of New York. Prepared scopes of work and cost estimates, coordinated work between disciplines, reviewed field investigation reports and remedial cost estimates and design specifications. Solicited bids from contractors.

Radioactive Waste Sites

Yucca Mountain, Nevada

Geohydrologist. Environmental Impact Study of a railroad intended to transport nuclear waste to the Yucca Mountain disposal facility. Analyzed groundwater extraction as a potential source of water for the construction of the rail line.

West Valley Demonstration Project

Geohydrologist. Conducted studies of the effectiveness of an in-situ reactive barrier for treatment of radionuclide-impacted groundwater.

Middlesex, New Jersey

Design Engineer and Geohydrologist. Performed groundwater modeling and conceptual design of groundwater containment systems for the RI/FS process at a FUSRAP site.

Shallow Landfill Disposal Area, Pennsylvania

Groundwater Modeler. Feasibility Study at a radioactive waste disposal site. Estimated groundwater extraction rates and volumes relevant to the remedial alternatives involving excavation of the contaminated material.

Electric Utilities

Niagara Power Authority, New York

Lead Geohydrologist and Groundwater Modeler. Relicensing of a power generation project in Niagara Falls, NY. Used an existing USGS regional ground water flow model of fractured bedrock to construct a local model of the study area. Analyzed the flow patterns in the complex fractured bedrock system to determine the influence of the Power Project on the ground water flow regime and the source of contaminant discharge into the City of Niagara Falls combined sewer system. The analysis involved specifying the effects of two 60-foot diameter conduits and a 1,000-acre reservoir. Designed an investigation of ground water infiltration into an 8 foot diameter storm water tunnel, excavated in fractured bedrock. Used the model and analytical techniques to determine the cause of infiltration. Coordinated work between various disciplines.

NYSDEC Sites

Kenwood Cleaners, New York

Lead Engineer. Design of the remediation system at the former dry cleaners site. Analyzed site data, developed the conceptual site model and performed analytical groundwater modeling and calculations. Developed and analyzed remedial alternatives. Developed cost estimates.

Polymer Applications, New York

Lead Engineer. Designed an aeration system for ex-situ remediation of the contaminated soils.

Kliegman Brothers, New York

Lead Geohydrologist. Investigation at a site contaminated with chlorinated solvents. Performed analytical modeling of hydrogeologic conditions at the site. Evaluated feasibility of hydraulic containment.

Chem Sales, New York

Lead Engineer. Remediation project at a former hazardous material sales/distribution NYS Superfund site. Designed and supervised the execution of a large-scale aquifer pumping test in a bedrock aquifer. Analyzed result of the test to determine aquifer parameters. Used the findings to design a long-term aquifer dewatering system intended to facilitate the site remediation by steam injection. Performed the preliminary design of the steam injection system. Coordinated work between various disciplines.

Kerry Chemical, New York

Groundwater Modeler. NYS Superfund project involving open excavation of contaminated soils and coal tar material from and area adjacent to a stream. Estimated dewatering rates and volumes for inclusion in the bid package.

Gratwick-Riverside Park, Niagara Falls, New York

Groundwater Modeler. RI/FS at the Gratwick-Riverside Park Superfund Site, a 53-acre site located adjacent to the Niagara River in Niagara Falls, New York. Performed detailed three-dimensional groundwater flow modeling of existing conditions and several combinations of remedial technologies (i.e. slurry walls, sheet piling, capping systems, extraction systems) were imposed. Analyzed the effectiveness of several proposed capping systems using the U.S. Army HELP model, which provides infiltration, surface runoff, and evapotranspiration rates for landfill caps.

NYSDEC Standby Contract, Camp Summit, Camp Georgetown and Camp Pharsalia Correctional Facilities, New York

Project Engineer and Groundwater Modeler. Responsible for defining parameters of several systems designed to process groundwater extracted during the dewatering of numerous open excavation pits at the state correctional facilities. Used analytical methods in conjunction with aquifer testing results to estimate the required dewatering rates and volumes of the extracted groundwater. Determined the dewatering times and sequences, defined design treatment rates and storage volumes for bidding purposes.

North Franklin Street Site, Watkins Glen, New York

Lead Engineer and Groundwater Modeler. Remediation project at a former dry cleaning facility in Watkins Glen, New York. The project included using a numerical groundwater flow model as a means of designing the optimum capture system for contaminated groundwater. Designed and conducted a field investigation, including and aquifer pumping test. Developed a groundwater flow model. Designed a groundwater extraction system and soil vapor extraction system. Analyzed system performance. Presented findings to the regulating agency.

Water Supply

Collins Correctional Facility, Collins, New York

Geohydrologist. Served a project involving an evaluation of a water supply system serving Collins Correctional Facility, Town of Collins, and Gowanda Village. Designed and analyzed an aquifer pumping test using existing wells at the Collins Correctional Facility. Assessed the potential for expanding the capacity of the system by installing new wells.

Groveland Correctional Facility, Sonyea, New York

Geohydrologist. Served a project involving evaluating groundwater conditions to increase the groundwater supply at the facility. Recommended installation of and two additional production wells. Performed testing of the expanded system.

Kirkwood Water Supply Project, Kirkwood, New York

Groundwater Modeler. Water supply project in Kirkwood, New York. The project included using groundwater flow modeling to analyze the interaction between a potable water production well field and a contaminated portion of the aquifer.

Private Industry

BASF, Toms River, New Jersey

Task Leader. Groundwater Extraction and Recharge portion of the Remedial Process Optimization effort for the large groundwater extraction and treatment Superfund site in Toms River, New Jersey. The approximately 1,300 gpm extraction/treatment/reinjection system has been operating since mid 1990s. Led an effort to optimize the extraction and monitoring portion of the system to improve efficiency and minimize cost. Prepared plans for the field investigation, data analysis and modeling to support the optimization evaluation and decision-making process. Supervised and coordinated the effort, presented findings to the client and the governing agency (USEPA). Coordinated the effort with the team working on optimizing the treatment portion of the system. Led the effort to prepare and submit pertinent reports, such as the RPO Analysis Reports, Long-Term Monitoring reports, and Remedial Investigation Work Plans.

Operable Unit 1 Group, Upper Black Eddy, Pennsylvania

Project Engineer. Feasibility Study at a Boarhead Superfund site in Upper Black Eddy, Pennsylvania. Designed bedrock fracturing investigation to evaluate options for improving the performance of the operating groundwater extraction system. Prepared a feasibility study of system modifications, including the evaluation of extraction system expansion and application of in-situ treatment technologies. Presented findings to the client (OU-1 Group), USEPA and PADEP.

El Paso, Fords, New Jersey

Engineer. Remedial design at the Former Nuodex Facility in Fords, New Jersey. The remediation involved a low-permeability subsurface flow barrier, a groundwater extraction and treatment system, excavation and capping. Prepared infiltration estimates and ground water flow analysis for the hydrologic design of the constructed wetlands and detention basins, and for the design of the groundwater extraction/containment system. Prepared and evaluation of the applicability of the phytopumping technology at the Site. Prepared design drawings for the groundwater extraction and conveyance system.

Pfizer, North Haven, Connecticut

Engineer. East Side Remedial Components design at the Pharmacia and Upjohn Site in North Haven, Connecticut. The design includes a subsurface low-permeability flow barrier, a well and trench groundwater extraction system, capping, and ecological improvements. Responsible for the preparation of remedy options evaluation and remedy design for the groundwater extraction and conveyance system. Supervised and coordinated work of junior staff.

T-Mobile Wayne Switch, Wayne, New Jersey

Project Engineer. Groundwater Interim Remedial Measure. The project objective was to eliminate the surface water discharge of contaminated groundwater infiltrating into a large-diameter storm sewer from the T-Mobile site. Designed an aeration system placed inside the storm sewer pipe. Coordinated project activities with the contractor and the stakeholders. Also, developed the design for the hydraulic containment system as part of the permanent site remedy under the RASR/RAW effort.

Republic Services, Oldmans Township, New Jersey

Project Engineer. Responsible for the preparation of the Focused Feasibility Study, Remedial Action Selection Report and the Remedial Action Work Plan for the former sump area at the BFI Pedricktown site. The remedy involved an excavation and off-site disposal of contaminated soil, capping and preparation of a deed notice.

Mercury Refining Company Remedial Design Group, Colonie, New York

Lead Engineer. Remediation project at a former mercury refining Superfund site. Prepared the Treatability Study for the Soil Stabilization/Solidification portion of the remedy. Responsible for developing the design documents for the site remedy, which included In-Situ Stabilization/Solidification and excavation of mercury-impacted deep and shallow soils, respectively, and excavation of mercury-impacted sediments. Participated in the work related to the support of the client's effort to negotiate with Site owners and with the USEPA regarding the overall remedial strategy, including planning of investigative activities, development of costs for alternative remedial approaches, and presentation of results to client and agency. Developed elements of the Remedial Design report, supervised and coordinated work of junior staff.

Novartis Site, Summit, New Jersey

Lead Engineer. Responsible for the preparation of a Focused Feasibility Study Report for the remediation of the dissolved-phase contamination in a bedrock aquifer.

Rohm and Hass Ringwood Morton International, Ringwood, Illinois

Groundwater Modeler. Remediation project at the Rohm and Haas facility in Ringwood, IL. Integrated the results of a regional hydrogeologic study by the Illinois State Water Survey and several local investigations by various consultants. Analyzed an aquifer pumping test. Developed a numerical groundwater flow model of the site, which included several aquifers and surface water bodies, as well as man-made features, such as water supply wells and leach fields. Applied the model to evaluate alternatives for the hydraulic containment of a plume of dissolved contamination migrating from the site. Developed a contaminant transport model simulating migration of the dissolved plume of several contaminants. Used the model to define the extent of the ground water management zone following the implementation of hydraulic containment. Designed the replacement for the existing hydraulic containment system. Assisted client during the installation of the hydraulic containment system. Evaluated system performance and designed the system expansion.

Bethlehem Steel Site, Buffalo, New York

Lead Engineer and Groundwater Modeler. Responsible for groundwater flow modeling and design of a groundwater interceptor trench for the remediation of various coal tar and petroleum sites at this former steel manufacturing facility. Performed hydraulic calculations and overall design of the trench, including cost estimates. Solicited bids from contractors. Presented findings to the client and regulating agencies.

Miller Brewing Company, Fulton, New York

Design Engineer. Participated in the design of a molasses injection system for the in-situ anaerobic remediation of an aquifer contaminated with chlorinated solvents. Analyzed data and evaluated system performance.

Ex Eaton Site, Batavia, New York

Lead Geohydrologist. Analyzed results of a pilot study of whey powder injection for the in-situ anaerobic remediation of an aquifer contaminated with chlorinated solvents. Prepared Pilot Study Evaluation Report, including recommendations.

GM Lansing, Lansing, Michigan

Groundwater Modeler. Remediation project at a 200-acre industrial facility in Lansing, MI. The project involved using a numerical groundwater flow model to analyze the interaction between a potable water well field and a 200-gpm groundwater extraction system installed in the contaminated part of the bedrock aquifer.

Sewerage

Southtowns Sewage Treatment Plant, Buffalo, New York

Modeler. Performed CORMIX plume modeling for the investigation of an existing diffuser conveying treated sewage into Lake Erie.

Erie County Sewer District #4, New York

Design Engineer. Performed flow monitoring and data interpretation. Performed hydraulic analysis of sewer system including gravity sewers, force mains, retention, and overflow facilities, and pump stations. Recommended design modifications.

Kings Highway, Amherst, New York

Design Engineer. Responsible for interpreting data from a TV sewer inspection for the Town of Amherst. Performed hydraulic calculations of sewer system and prepared cost estimates for proposed modifications.

Big Sister ORF, Buffalo, New York

Civil Engineer. Assisting in the design of a retention/overflow facility.

Wanakah Pump Station, Hamburg, New York

Civil Engineer. Performing flow monitoring and hydraulic calculations for the Wanakah Pump Station in Hamburg, New York.

Sub-Slab Depressurizing Systems

New York City School Construction Authority, New York, New York

Lead Engineer. Designed soil vapor barriers and sub-slab depressurization systems for two new school buildings. Prepared drawings and specifications, as well as cost estimates. Coordinated work of various disciplines.

Publications

1. Jacobi, J.W., Ostrowski, M., and Lysiak, J., 1996, Groundwater Extraction and Treatment, Twenty-Eighth Mid-Atlantic Industrial and Hazardous Waste Conference, SUNY at Buffalo.
2. Leonard, J.E. et al., 2002, Managing Hazardous Materials, Institute of Hazardous Materials Management.
3. Ostrowski, M., and Caputi, J., 2012, Treatability Study to Support the Full-Scale Application of In-Situ Stabilization/Solidification of Mercury-Contaminated Soils at a Superfund Site in New York, Eighth International Conference on Remediation of Chlorinated and Recalcitrant Compounds.

Principal Scientist

Gregory J. Cole

Experience Summary

Mr. Cole has 28 years of experience in environmental chemistry, project management, data management and site assessment. He is knowledgeable in EPA methods for the analysis of air, soil, water and waste. His breadth of experience includes organic, inorganic and radioanalytical chemistry methodology and he provides assistance on chemistry-related issues, such as fate and transport of different chemical compounds and fuel fingerprinting. Greg performs data validation and laboratory audits for accurate and defensible laboratory data, and interprets laboratory data to makes recommendations for further sampling for proper site evaluation. He has extensive knowledge of hydrocarbon analysis, including identifying and quantizing specific fuels and oils, and provides chemistry and data management support to project teams performing remedial investigations, engineering evaluation/cost analyses and groundwater monitoring. Greg has investigated fuels contaminated groundwater sites to determine the source of contamination when multiple sources were possible.

Assignment

QA/QC Officer

Education

B.S., Psychobiology (with Chemistry Minor), University of California at Los Angeles, Los Angeles, CA, 1983

Experience

28 years

Training

40-hour OSHA Health & Safety HAZWOPER Training, 1997

8-hour HARWOPER Supervisor/Site Safety Officer Training, 2003

8-hour Refresher OSHA Training, 2005

Adult CPR Training, 2005

Standard First Aid Training, 2005

3-hour Work Zone Safety Training, 1999

Total Quality Management Training, 1996

Title 22 Hazardous Waste Generator Training, 1995

DOT HM-181/Performance Oriented Packaging Training, 1999

DOT HM-126F/HazMat Employee Training, 1995

TQM 40-hour Training, 1991

Joined Firm

2002

Relevant Expertise

- *Environmental chemistry*
- *Data management*
- *Site assessment*

Advanced Treatment Technology Pilot Project, Sacramento Regional County Sanitation District, Sacramento, California

Program Chemist/QA/QC. This project involves the design, construction and operation of a pilot plant to test biological nutrient removal, filtration and disinfection alternatives at the Sacramento Regional Wastewater Treatment Plant. This pilot project is on the critical path to helping the District meet stringent National Pollution Discharge Elimination System permit requirements by December 2020, specifically in regards to ammonia and nutrients. Greg verifies the analytical laboratory data for this pilot project. The data set includes an extensive compound list that involves numerous analytical methods and multiple laboratories. He confirms that the database is a complete and accurate representation of the laboratory analytical data. He also checks that laboratory data meets project requirements, and that any warranted validation qualifiers are added and are properly associated with results.

Stormwater Compliance Services, California Department of Transportation (Caltrans), Sacramento, California

Program Chemist. This contract includes providing fulltime field assistance to District 4 for stormwater compliance at Caltrans construction sites, such as developing seed testing procedures for seed that is applied to Caltrans construction sites for erosion control, and managing compliance assistance task orders for the Construction and Maintenance Divisions to supply in field assistance to the Districts for a variety of stormwater-related activities. Greg is providing expertise in analytical laboratory analyses and testing. He also interacts with analytical laboratories to help ensure that proper analytical methods are being used and that data is properly qualified for end users.

Delivery Order 29 Planning and Engineering Studies for FY10 Projects, Design-Build Request for Proposal Packages for Water, Wastewater and Recycled Water Improvement Programs, Marine Corps Base Camp Pendleton, U. S. Navy, Naval Facilities Engineering Command, Southwest Division, Oceanside, California

Program Chemist. The objective of this project was to provide a wide variety of engineering services, including preparing planning and engineering studies, cost estimates, and design-build request for proposals for various water, wastewater and recycled water improvement projects at Camp Pendleton. Greg was responsible for laboratory actives and provided data users with properly qualified data.

Domestic Well Monitoring, Atlantic Richfield (BP), Nevada

Program Chemist. BC is performing semi-annual well sampling for approximately 155 domestic wells and quarterly sampling for 75 wells. Greg is responsible for confirming that analytical data is defensible and QAPP procedures have been followed. [31981; Dec 2011 est; $314K]

Total Dissolved Solids (TDS) Facility Predesign, City of Quincy, Washington

Program Chemist. BC completed the preliminary design for a brine evaporation pond. The facility helps manage TDS in the industrial and municipal sewer systems by providing a discharge for concentrated brine from pretreatment of data center cooling tower water makeup water or treatment of data center cooling water blowdown for recycling. Greg performed data verification and validation and confirmed the integrity of data stored in the project database. [27385; July 2010; $14K]

Monitor Well Completion, Atlantic Richfield (BP), Nevada

Program Chemist. This project includes well monitoring, including sampling and analysis, hydraulic testing and data evaluation, database management and 3-dimension data visualization. Greg is the program chemist responsible for confirming that analytical data is defensible and QAPP procedures have been followed. [31983; Dec 2011 est; $2.1M]

Groundwater Remedial Investigation Activities, Atlantic Richfield (BP), Nevada

Program Chemist. BC is evaluating hydrologic tracers for 55 wells, preparing an interim data summary report of field activities, developing a 3-dimension visualization tool, and submitting a Groundwater Remedial Investigation Work Plan. Greg is the program chemist responsible for confirming that analytical data is defensible and that QAPP procedures have been followed. [31977; Dec 2011 est; $403K]

El Paso Weston Sampling Oversight, El Paso Corporation, New Jersey

Program Chemist. Greg is performing data verification, confirming that project database is complete and accurate. [33114; Aug 2011; $72K]

Cover Materials Evaluation, Atlantic Richfield (BP), Nevada

Program Chemist. Greg is responsible for confirming that analytical data is defensible and QAPP procedures have been followed. The project includes compiling laboratory data for geotechnical, geochemical and plant growth parameters, and preparing a data summary report to rank material types based on the analytical results. [31988; Dec 2022 est; $135K]

DQ University Remediation and Feasibility Study, Yolo County, California

Program Chemist. This project involves performing a remedial action and preparing decision documents for the ultimate goal of completing the Formerly Used Defense Site (FUDS) work at the D-Q University Site. Greg works with the USACE chemist to help meet all data requirements. [27631; June 2013 est; $441K]

Site-wide Groundwater Modeling, Atlantic Richfield (BP), Nevada

Program Chemist. This project includes measuring and sampling more than 250 wells, purchasing and installing new well sampling equipment, and compiling groundwater evaluation and chemical data. Greg is the program chemist responsible for confirming that analytical data is defensible and QAPP procedures have been followed. [31928; Dec 2011 est; $1.5M]

Yerington Groundwater Areas of Concern, Atlantic Richfield (BP), Nevada

Program Chemist. Greg is responsible for confirming that analytical data is defensible and QAPP procedures have been followed. Project elements include site-wide groundwater monitoring, well sampling, Pumpback Well System (PWS) characterization, a site-wide groundwater remedial investigation work plan, and a bottled water program. [24584, 24572 and 24578]

Remedial Design Investigation, Mercury Refining PRP Group, Albany, New York

Program Chemist. Greg is performing data validation, data verification and writing data quality summaries. [26882; est. Jan 2020; $455K]

Camp Pendleton DO29 Engineering Studies, US Navy NAVFAC Southwest, San Diego, California

Program Chemist. BC is preparing planning and engineering studies, cost estimates, and design-build request for proposals (RFPs) for five projects at Camp Pendleton. Greg is responsible for confirming that laboratories understand the project requirements and. He also provides the data users with properly qualified data. [9881; est. Sept 2011; $4.2M]

Remedial Investigation and Feasibility Study, Confidential Client, North Carolina
Program Chemist. Greg was responsible for data validation and confirming that the project database was complete and accurate [9944; Aug 2010; $652K]

Third Party Remediation, Confidential Client, San Diego, California
Program Chemist. For this third party remediation oversight of petroleum-impacted soil from an operating oil field, Greg worked with the laboratory to set up proper procedures and confirms the data is properly validated and available for use. [25301, 11008 and 29954]

Zinc Remedial Investigation and Feasibility Study, Freeport-McMoRan Cop and Gold, Langeloth, Pennsylvania
Program Chemist. Greg is responsible for confirming that the project database is complete and accurate for this remedial investigation and feasibility study at a former Zinc Smelter.. [20222; est. Aug 2011; $202K]

Ras Valley Surface Water, Nu-West Industries, Caribou County, Idaho
Program Chemist. Greg works between the laboratory and the regulatory agencies to ensure that laboratory analyses and data meet tproject needs. [26417; Mar 2011; $240K]

Bartlett Tree Company Site, F.A. Bartlett Tree Expert Company, Nassau County New York
Program Chemist. Greg oversees the environmental testing laboratories and data verification and validation of project data. He produces data usability summary reports (DUSRs) that describe data quality and provide data qualifiers that warn data users of potential biases for individual results. Greg evaluates the appropriateness of sampling and analytical methods and laboratory quality systems, and makes recommendations to improve quality and efficiency of the sampling and analytical process.

Putnam Ash Residue Landfill, Wheelabrator Putnam Inc., Putnam, Connecticut
Program Chemist. Greg oversees the environmental testing laboratories and data verification and validation of project data. He produces validation reports that describe data quality and provide data qualifiers that warn data users of potential biases for individual results. Greg evaluates the appropriateness of sampling and analytical methods and laboratory quality systems. He makes recommendations to improve quality and efficiency of the sampling and analytical process.

Paso Robles Site, California Portland Cement Company, Paso Robles, California
Program Chemist. Greg oversees the environmental testing laboratories and data verification and validation of project data. He produces validation reports that describe data quality and provide data qualifiers that warn data users of potential biases for individual results. Greg evaluates the appropriateness of sampling and analytical methods and laboratory quality systems. ($500K, ongoing)

Former Deluxe Facility, Deluxe Corporation, Clifton, New Jersey
Program Chemist. Greg oversees the environmental testing laboratories for this multi matrix site. He evaluates the appropriateness of sampling and analytical methods and laboratory quality systems for the analysis of soil gas, indoor air, groundwater and soil. Greg ensures that the project database is complete and accurate and that all validation qualifiers are properly entered into the project database. He makes recommendations to improve quality and efficiency of the sampling and analytical process. ($1.7M, ongoing)

Former Nuodex Corporation Facility, El Paso Energy Corporation, Fords, New Jersey
Program Chemist. Greg oversees the environmental testing laboratories. He evaluates the appropriateness of sampling and analytical methods and laboratory quality systems. Greg oversees subcontracted activities for data verification and third party validation. He ensures that the project database is complete and accurate and that all validation qualifiers are properly entered into the project database. He makes recommendations to improve quality and efficiency of the sampling and analytical process.

Yerington Mine Site, Atlantic Richfield Company, Yerington, Nevada

Program Chemist. Greg oversaw the environmental testing laboratories including technical systems audits. He evaluated the appropriateness of sampling and analytical methods and laboratory quality systems and oversaw subcontracted activities for data verification and third party validation. Greg confirmed that the project database was complete and accurate and all validation qualifiers were properly entered into the project database. He produced data quality summaries for inclusion in monitoring and investigation reports and made recommendations to improve quality and efficiency of the sampling and analytical process. [$3M, 2006]

Site Remediation and Closure, Formerly Used Defense Sites, U.S. Army Corps of Engineers (USACE), Sacramento District, Benicia, California

Program Chemist. Greg was responsible for overseeing all environmental testing laboratories, including technical systems audits for existing contracts with USACE. He oversaw subcontracted activities for data verification and third party validation. He worked with a USACE-sponsored automated data review tool developed by Laboratory Data Consultants for review of data produced for the Benicia Arsenal project. Greg participated in the development and review of multiple project specific field site investigation plans and project reports. He prepared and submitted quality control summary reports, a requirement of USACE indicating data quality.

Regional Surface Water Supply Plan, Turlock Irrigation District, California

Project Chemist. The BC team evaluated appropriate treatment technologies based on historical raw water quality and analyzed cost-effective routing for pipelines to each of the communities. Subsequent phases of the project included a pilot study to refine the process selection, water quality monitoring and sanitary survey, final design for the raw water system and final design for the new treatment plant and transmission components of the project. Greg was responsible for completing field and laboratory data and confirming accuracy. He also worked with the laboratories to confirm the data would meet project requirements.

State Route 73 Detention Basin Monitoring, Caltrans, Orange County, California

Program Chemist and Data QA/QC. Greg provided recommendations for program changes and oversight of stormwater data analysis for this large stormwater monitoring project. He interfaced with ATL Laboratories and evaluated QA/QC for project data.

Red Bluff National Guard Armory Groundwater Monitoring and Remediation/Site Closure, U.S. Army Corps of Engineers, Sacramento District, Red Bluff, California

Project Manager. Greg managed the groundwater monitoring and reporting for the Red Bluff Armory site starting in 2002. Activities included quarterly sampling and reporting, an annual report and a Quality Control Summary Report. He performed all data verification and analysis for the project. He also worked to get the site up-to-date with State Geotracker requirements. [$480K, 2009]

Crystal Cove State Beach Park Stormwater Monitoring, California Department of Transportation (Caltrans), Laguna Beach, California

Program Chemist and Data QA/QC. Greg oversaw stormwater data analysis for this project. He interfaced with ATL Laboratories and evaluated QA/QC for project data.

Red Bluff National Guard Armory Free Product Removal, U.S. Army Corps of Engineers, Sacramento District, Red Bluff, California

Project Manager. Greg conducted free product removal for the Red Bluff Armory site. His responsibilities included meeting with California Regional Water Quality Control Board Central Valley Region and free product removal activities. He performed all data verification and analysis for the project.

Groundwater Investigation, Confidential Air Force Base, California

Project Manager. Greg managed the groundwater investigation at an Air Force Base former gas station site. His activities included writing site investigation and assessment reports, quarterly monitoring and reporting, and interfacing with regulatory agencies. He performed all data verification and analysis for the project. The site will advance to closure under Regional Board guidelines.

Surface Water Supply Study, Turlock Irrigation District, California

Project Chemist and QA/QC Officer. This project involved extensive analyses of surface water samples to determine if the source river water is acceptable as a drinking water source. Greg was responsible for procuring laboratories and acted as the laboratory contact. Greg also evaluated all analytical results for usability and was heavily involved in writing and reviewing the QAPP and monitoring plan for this project.

Open Burn/Open Detonation Area Closure Project for Camp Navajo, State of Arizona Army National Guard, Bellemont, Arizona

QC Manager. Greg was responsible for conducting or managing audits of field and laboratory activities, validation of field and analytical data, and audits of data processing and file maintenance.

Diesel Spill Investigation and Cleanup, Gulf Insurance Company, Navarro, California

Project Chemist. BC performed the investigation and cleanup for a 4,000-gallon diesel spill site in rural Mendocino County. The project involved remediation system design, temporary remedial actions implementation, documentating all activities, acquiring access to implement investigation and remedial actions, and remedial systems installation and operation for contaminants including diesel and MTBE.

Jacobs Engineering Group Inc., Sacramento, California

Senior Chemist. Greg oversaw chemistry and data management functions for the U.S. Army Corps of Engineers Sacramento District's Benicia Arsenal project.

Jacobs Engineering Group Inc., Sacramento, California

Senior Chemist. Greg provided chemistry and data management support to field sampling teams and project management. This required strong knowledge of organic, inorganic and radioanalytical chemistry laboratory methods. He trained chemists and data managers to perform tasks related to processing field and laboratory data. He met with clients and regulators to determine initial project requirements and/or resolve comments and concerns. He wrote Data Quality Assessments, Field Sampling Plans (FSPs), Remedial Investigation Characterization Summaries (RICS), Data Management Plans and laboratory Statements of Work. He performed senior reviews of Quality Assurance Project Plans, FSPs and RICS reports. He also performed laboratory audits and documented deficiencies in audit reports as well as data verification/validation of laboratory reports. He performed or managed most tasks related to providing clients with high quality deliverables, from determining client requirements to final report delivery.

Air Toxics Ltd., Folsom, California

Support Services Supervisor. Greg supervised personnel in the HPLC and extractions laboratories, SUMMA canister cleaning and shipping department, and VOST tube preparation area. He developed the laboratory procedures for the analysis of aldehydes and ketones by Methods TO-5, TO-11 and CARB 430. He developed HPLC analytical parameters, performed instrument calibration, troubleshooting guidelines and MDL studies. Greg increased overall productivity and quality of laboratory analyses. He trained analysts in proper analytical techniques. He was responsible for the preparation of all air sampling media including DNPH sampling impingers, TO-11 cartridges, PUF/XAD-2 sampling cartridges and VOST tubes.

Western Environmental Sciences and Technology Laboratory, Davis, California

Laboratory Supervisor. Greg was responsible for the organic extractions and fuels analysis laboratories. He also was responsible for coordinating the activities of six technicians to process incoming samples in an efficient manner. He performed gas chromatographic (GC) analyses, processed data and issued laboratory reports for fuel analyses using LUFT methods. He developed several analytical methods to help the laboratory become a full service environmental analytical laboratory.

Chemwest Analytical Laboratories, Sacramento, California

Supervising Lead Chemist. Greg was responsible for the training and supervision of four technicians in the organics and dioxins extraction laboratories. He performed volatile analysis using gas chromatography/mass spectroscopy (GC/MS). He developed improved methods for washing glassware, eliminating a continuing source of laboratory contamination. He implemented safety procedures to decrease exposure to employees.

NET Pacific, Santa Rosa, California

Team Leader, Extractions Laboratory. Greg was responsible for the training and supervision of five technicians in the organics extraction laboratory. He increased automation to allow for greater production with fewer man-hours. He maintained sample tracking information in the laboratory database and confirmed samples were processed rapidly while maintaining quality of results.

Radian Corporation, Sacramento, California

Supervisor, Sample Preparation Laboratory. Greg was responsible for the training and supervision of seven technicians in the organics extraction laboratory. He increased production by doubling the number of soxhlet and continuous liquid-liquid extractors and streamlining procedures. He repaired GCs and performed troubleshooting and maintenance for various instruments. He developed an analytical method for herbicides, which reduced the hazards and increased the recoveries of target analytes. Greg acted as the back-up Laboratory Manager, responsible for all laboratory operations during the laboratory manager’s absence.