GM COMPONENTS HOLDINGS, LLC
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK
BUILDING 8 SITE #932139
REVISED REMEDIAL INVESTIGATION WORK PLAN

PREPARED FOR:
New York State Department of Environmental Conservation

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GM COMPONENTS HOLDINGS, LLC
LOCKPORT, NEW YORK
BUILDING 8 SITE ID #C932139
BROWNFIELD CLEANUP PROGRAM
REMEDIAL INVESTIGATION WORK PLAN
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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Remedial Investigation Work Plan (RIWP) is to describe activities planned for the implementation of the Remedial Investigation (RI) associated with Building 8 (Site ID # C932139) at the GM Components Holdings, LLC (GMCH) Lockport Facility, located at 200 Upper Mountain Road, in the City of Lockport, New York (see Figure 1).

The work described in this RIWP is being done under a New York State Department of Environmental Conservation (NYSDEC) Brownfield Cleanup Program (BCP) Agreement. GZA GeoEnvironmental of New York (GZA) will be responsible for completing the RI for Building 8.

It should be noted that there are three separate BCP Sites associated with the GMCH Lockport Facility, as follows.

- GM Components Holdings, LLC Building 7, site ID #C932138 (Building 7)
- GM Components Holdings, LLC Building 8, site ID #C932139 (Building 8)
- GM Components Holdings, LLC Building 10, site ID #C932140 (Building 10)

This RIWP has been developed for the work associated with Building 8. Separate RIWPs have been developed for the work associated with Building 7 and Building 10.

1.2 PROPERTY DESCRIPTION

The GMCH facility is located at 200 Upper Mountain Road in both the City and Town of Lockport, which is located in Niagara County, New York. The portion of the facility which includes Building 10 is located within the City of Lockport.

The GMCH facility is approximately 342 acres in size and located in an area of mixed residential, agricultural, commercial, and industrial settings along Upper Mountain Road. Building 8 constitutes approximately 13 of the 342 acres and is located in the northern central portion of the GMCH facility. Across Upper Mountain Road, the Niagara Escarpment is located approximately one-half mile to the northeast. A stone quarry and former steel facility are located approximately 1 mile south of GMCH. Residential properties are generally present along the east and north sides of Upper Mountain Road and to the west.

Within the facility, Building 7, Building 8, and Building 9 are dedicated to manufacturing and engineering. Building 10 has been converted to house new manufacturing operations staffed by non-GMCH personnel in the northern portion with the southern portion being used by GMCH as a warehouse. Building 6 has been leased to Delphi Properties Management, LLC for vehicle component engineering and testing (see Figure 2).

1.3 BACKGROUND

GMCH currently owns and operates an automotive component manufacturing facility along Upper Mountain Road in the City and Town of Lockport, New York. The facility was initially developed in 1937 on vacant agricultural land and orchards. The Site was developed as part of the radiator manufacturing operation, formerly located in downtown Lockport. Manufacturing operations began at the facility along Upper Mountain Road in 1939.

General Motors Corporation owned and operated the facility until it was conveyed to Delphi Automotive Systems, LLC (Delphi) in December 1998. In June 2009, General Motors Corporation filed for Chapter 11 bankruptcy protection and it is now known as Motors Liquidation Company (MLC).

A new company was created to purchase certain assets of MLC and the current name of that entity is General Motors LLC (GM). A GM subsidiary, known as GMCH, took title from Delphi the portion of the facility that includes Building 8 in October 2009.

Building 8 was constructed in phases between 1960 and 1966 and was utilized for manufacturing since its construction. The northern portion of the building is being used for storage of product and unused equipment and manufacturing is still on-going in the southern portion.

In 2006, a voluntary facility-wide investigation of soil and groundwater conditions at the facility was conducted. The first phase of that work was the development of a Current Conditions Summary (CCS) which was completed by Environmental Resource Management (ERM). The CCS work generally followed the requirements for a CCS in the RCRA Corrective Action Program and we believe it was comprehensive, comparable to an initial BCP or State Superfund investigation.

After completion of the CCS, a field investigation, also completed by ERM, was initiated to assess soil and groundwater conditions at the 50 areas of interest (AOI), identified by the CCS. A total of 144 soil borings were completed, nine sediment and four surface soil samples were collected. Six monitoring wells were installed, but only five were sampled as one of the wells was dry. Over 400 soil and groundwater samples were collected from the 144 soil borings and analyzed for an extensive list of parameters, which included volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals and polychlorinated biphenyls (PCBs). The field investigation activities and results were described in the Field Investigation Report (FIR) that was submitted to the NYSDEC Region 9 office in January 2007, followed by the CCS submission in May 2007.

Three (3) AOIs located within the footprint of the Building 8 BCP site were investigated as part of the field investigation. Thirty-two (32) soil probes were completed to assess the AOIs (see Figure 3). At each AOI, samples were analyzed for VOCs, SVOCs, PCBs, and metals. These AOIs are shown on Figure 3 and are as follows.

- AOI-18 was a former chromium sump area in the central portion of the building.
- AOI-22 was six (6) former degreasing locations located throughout the building.
- AOI-23 was a historic press operations area in the northeastern portion of the building.

The investigation identified elevated levels of chlorinated solvents in soils beneath one former degreaser area (AOI-22) in the southeastern interior of Building 8, as well as chlorinated solvents in groundwater south of the building. Arsenic and benzo(a)pyrene were also detected at elevated levels at AOI-18 and AOI-23, respectively.

Boring 8-001-G was one of nine borings completed within AOI-18. Results of the soil samples from 8-001-G; 2 to 4 feet indicated that arsenic was detected at a concentration of 65.8 parts per million (ppm) in a sample collected from 2 to 4 feet below the building slab. This detection of arsenic is above its NYSDEC Part 375 Industrial Soil Cleanup Objective (ISCO) of 16 ppm. No other compounds were detected above their respective Industrial SCO in the samples collected to address AOI-18. This detection is not considered to be significant as arsenic is not mobile in soil, its detection was limited to one location at a depth of 2 to 4 feet, which is above the groundwater table in this area of the site.

Boring 8-006-F was one of seven borings completed to address AOI-23. Benzo(a)pyrene was detected at a concentration of 1.4 ppm in a sample collected from 8-006-F; 0 to 1.5 feet below the building slab. This detection of benzo(a)pyrene is above its NYSDEC Part 375 ISCO of 1.1 ppm. This detection is not considered to be significant as SVOCs are not mobile in soil, its detection was limited to one location at a depth of 0 to 1.5 feet, which is above the groundwater table in this area of the site. No other compounds were detected above their respective Industrial SCO in the samples collected to address AOI-23.

Boring 8-005-3C was one of 16 borings completed to address AOI-22, the six (6) former degreaser locations. Trichloroethene (TCE) was detected at a concentration of 1,000 ppm in a sample collected from 8-005-3C; 8 to 10 feet below the building slab. This detection of TCE is above its NYSDEC Part 375 Industrial Soil Cleanup Objective of 400 ppm. No other compounds were detected above their respective Industrial SCO in the samples collected to address AOI-22.

1.4 INVESTIGATION OBJECTIVES

The objectives of this RI is to obtain Site specific data on the nature and extent of potential soil and groundwater contamination and the degree to which the potential contamination poses a threat to human health and the environment. On March 18, 2010 GMCH met with NYSDEC to discuss the three BCP sites; NYSDEC acknowledged that VOCs would be the focus of the investigation based on the previous investigation conducted in Building 8.

Proposed soil borings, soil probes, indoor air and subslab sample locations, and bedrock monitoring wells related to the Building 8 RI are shown on Figure 4. As there are also RIs occurring related to the Buildings 7 and 10 BCP Sites, the number of explorations associated with Building 8 is limited to the Building 8 BCP Site footprint and downgradient (east) between Building 8 and Building 6 (see Figure 4). It should be noted that the RIs for the three BCP Sites at the Lockport facility will be conducted concurrently. Consequently, although the focus of the BCP Agreement for Bldg 8 is on an evaluation of environmental conditions at the site known as Bldg 8 (with an approximate acreage of 13.1 acres - see paragraph II of the BCP Agreement), the data generated from the neighboring BCP sites and from other facility-wide investigations that are being conducted (for example, 18 existing monitoring wells will be sampled in 2010 as part of other on-going monitoring and/or investigations (see Figure 4)) will be considered as part of that investigation.

This RI will involve test borings, monitoring well installation, soil probes, vapor intrusion assessment and analytical sample collection.

The specific objectives of the RI are as follows:

- Further assess Site geology;
- Further assess hydrogeology;
- Evaluate extent of contamination;
- Evaluate transport mechanisms;
- Assess the potential source(s) of contamination and assess impact to soil and groundwater; and
- Identify potential pathways for human exposure as part of a qualitative risk assessment.

2.0 DESCRIPTION OF FIELD ACTIVITIES

The field activities described below are intended to accomplish the objectives of the RI.

2.1 GENERAL FIELD ACTIVITIES

General field activities include site meetings, mobilization, implementing the health and safety plan, test borings, sampling and analytical testing, decontamination and handling of investigation wastes, and surveying. Subcontractors will be used for drilling, analytical testing and surveying.

2.1.1 Site Meeting

A Site "kick-off" meeting will be held with GMCH, GZA and the drilling subcontractor(s) prior to initiating field work activities. The purpose of the meeting will be to orient field team members, GMCH staff and subcontractors with the Site, project personnel, Site background, scope of work, potential dangers, health and safety requirements, GMCH site-specific security and safety protocols, emergency contingencies and other field procedures. NYSDEC staff are welcome to attend and will be notified at least seven (7) days in advance of the meeting.

2.1.2 Mobilization

Following approval of the RI Work Plan by NYSDEC, the Underground Facilities Protection Organization (UFPO) will be contacted at 1-800-962-7962 to clear exploration locations. Utility clearance will require three working days by UFPO. Additionally, an Excavation Permit (Environmental Management System Work Instruction 014) will need to be obtained from GMCH Plant Engineering. This will require that exploration locations be approved by GMCH Plant Engineering prior to starting the investigation. GZA and its subcontractors then will mobilize necessary materials and equipment to the Site.

2.1.3 Health and Safety

It is anticipated that the work to be completed at the Site will be done at level D personal protection. Should health and safety monitoring during field activities indicate a threat to field personnel or warrant an upgrade to level C protection, work will stop, Site conditions will be re-evaluated prior to further investigation activities. See Section 5.0 for additional information on Health and Safety.

2.1.4 Decontamination and Handling of Investigation Derived Waste

Decontamination procedures for the field activities are described in the Equipment Decontamination Field Method Guideline (FMG) included in Appendix A. Personal protective equipment (i.e., latex gloves) and disposable sampling equipment (i.e., polyethylene tubing) will be placed in plastic garbage bags for disposal as a solid waste at the Site.

Excess soil cuttings from test borings and/or soil probes will be drummed and stored on-Site for future disposal. Soil will be characterized for proper disposal at a landfill facility permitted to accept the soil cuttings based on the waste characterization results (i.e., non-hazardous or hazardous). Waste characterization sample analysis will be based on the sampling requirements of the disposal facility selected.

Purge water and well development water will be containerized in 55-gallon drums and stored until analytical results are received. If analytical results are within permissible acceptable limits for discharge to the City of Lockport wastewater treatment facility and authorization is received to do so, drummed water will be discharged to the sanitary sewer. If analytical results do not permit discharge to the sanitary sewer, drummed water will be sampled and characterized for proper disposal. Waste characterization sample analysis will be based on the sampling requirements of the disposal facility selected.

The quantities and volumes of investigation derived waste (IDW) to be generated are unknown and will be managed in accordance with the Waste Characterization Field Method Guide (FMG) in Appendix A.

2.1.5 Survey

Following completion of the RI investigation, a professional land surveying firm (McIntosh & McIntosh, P.C.) will be subcontracted to locate exploration locations and prepare a Site base map.

2.2 RI FIELD INVESTIGATIONS

RI field work will generally be done in compliance with NYSDEC's Draft DER-10 "Technical Guidance for Site Investigation and Remediation", dated June 2010. On March 18, 2010 GMCH met with NYSDEC to discuss the three BCP sites. NYSDEC acknowledged that VOCs would be the focus of the investigation based on the previous investigation conducted in Building 8.

2.2.1 Vapor Intrusion Assessment

A product inventory is typically required prior to conducting a vapor intrusion assessment. GMCH maintains a database of chemicals and chemical products stored and used within Building 8. A copy of the database will be provided for review prior to completing the air sampling. The purpose of the product inventory review will be to determine if compounds of concern (PCE, TCE, cis-DCE, trans DCE and VC) are present within products and chemicals currently used within Building 8 that have the potential to create interference or bias in the air sampling results. Prior to initiating the air sampling, GZA will review the product inventory list to determine if chemicals or products need to be removed from the sampling area at least 24 hours prior to the sampling event.

During the air sampling event, GZA will make observations of the chemicals and chemical products in the areas of the sampling to determine the completeness of the database provided by GMCH. Additionally, a photoionization detector (PID), which can screen levels down to the part per billion (ppb) range, will be used to screen individual containers observed and determine background levels within the sampling areas.

Three types of air samples (sub-slab, ambient indoor, and ambient outdoor) will be collected as part of the vapor intrusion assessment. The samples will be collected via methodologies identified in the New York State Department of Health, "Guidance for Evaluating Soil Vapor Intrusion in the State of New York", dated October 2006 (NYSDOH Document) and the Soil Vapor Monitoring Point Sampling Procedure FMG in Appendix A.

Five (5) indoor air sample locations are proposed within Building 8 (see Figure 5). The indoor air samples will be collected from the breathing zone or approximately 4 to 5 feet above the slab-on-grade floor.

Five (5) sub-slab air samples are proposed within Building 8. The sub-slab samples will be collected from under the slab-on-grade floor through an approximate 1/2-inch diameter hole drilled in a competent portion of the concrete floor away from cracks or drains. Clean, dedicated polyethylene tubing will be placed into the hole to a depth approximately 2-inches below the concrete slab and sealed at the floor surface with modeling clay. The sub-slab air samples will be collected from within 10 feet of the indoor air sample locations (see Figure 5 for approximate locations).

One ambient outdoor air sample will be collected from an exterior upwind location of Building 8. The outdoor air sample will be collected from approximately 4 to 5 feet above the ground surface on the day of the indoor air sampling event.

The air sampling will be completed using dedicated, laboratory-supplied flow regulators and sample canisters for an eight-hour duration (e.g., standard shift duration in a commercial/industrial facility) in accordance with NYSDOH Document. Air samples will be collected using a one-liter sampling canisters and will be analyzed via USEPA Method TO-15 for the volatile organic compounds (VOCs).

2.2.2 Test Boring, Monitoring Well Installation and Sampling

Four (4) permanent monitoring wells will be installed as part of the Building 8 RI, three (3) inside of the building and one (1) downgradient of Building 8 (see Figure 5). Based on previous work done at the GMCH property in this area, bedrock is at a depth of approximately 7 feet below ground surface (bgs). Groundwater at the Site is typically present in the vicinity of the overburden soil and bedrock interface.

Test borings for monitoring well installation will be advanced in the overburden soils using a track or truck mounted rotary drill rig using 6 ¼ inch inside diameter hollow stem augers (HSA). Overburden soil samples will be obtained by driving a 1 3/8 inch inside diameter by 24 inch long split spoon sampler 24 inches ahead of the lead cutting shoe of the HAS. The test borings will be completed as outlined in the Soil Boring FMG in Appendix A.

Soil samples collected from the test borings will be classified in the field by visual examination in accordance with the Soil Classification FMG in Appendix A. Boring logs that identify appropriate stratification lines, blow counts (if applicable), sample identification, sample depth interval and recovery, and date will be generated for each test boring and included as an appendix to the RI report.

The HSAs will be advanced until refusal is encountered. Drilling fluids will not be used while advancing the HSA in the overburden, so groundwater can be identified, if encountered. Once bedrock is encountered, the upper 2 feet of bedrock will be drilled using a 5 7/8 inch roller bit to set a 4 inch diameter steel casing. The steel casing will be installed, grouted into place and allowed to set up for at least 24 hours before drilling activities continue at the respective location. Once the grout around the casing has set up, a 3 7/8 inch diameter rock core barrel will be used to complete the boring to the designated depth, assumed to be approximately 15 feet bgs.

The rock core samples will be logged including run number, sample interval, length of sample recovered, rock quality designation (RQD), depth where drill water was lost, and a description of the rock mass and individual discontinuities (bedding planes, joints, voids, etc.). This information will be included on the boring logs. Rock core samples will be placed in wooden core boxes, photographed and labeled with the project name and number, boring number, run number, depth interval of the run and date. The rock core boxes shall be stored by GMCH for 1 year. The bedrock coring will be completed as outlined in the Bedrock Coring and Rock Classification FMGs in Appendix A.

After the designated depth has been reached, the completed test boring will be converted to a groundwater monitoring well. The well will be constructed of 2 inch inner diameter flush coupled PVC riser and screen. The screen will consist of an approximate 5 to 7 foot long section of machine slotted PVC. A sand filter will be placed in the boring around the annulus space of the well screen such that the sand extends a minimum of 1-foot above the top of the screen. An approximate 3-foot thick layer of bentonite will be placed above the sand filter to provide a seal from the overburden conditions above the screen. A mixture of cement/bentonite grout will extend from the bentonite seal to approximately 1-feet bgs. The monitoring well will be completed by placing a flush mounted road box over the riser. Concrete will be placed in the boring around the protective casing and sloped away from the casing. The monitoring wells will be installed as outlined in the Well Construction Materials and Deep Bedrock Wells FMG in Appendix A.

The soil cuttings generated from the test boring will be placed in 55-gallon drums for disposal by GMCH. The drums will be labeled with date and location and staged in a secure area at the Site approved by GMCH. GZA assumes the soil spoils generated from the test borings will not be contaminated. Procedures discussed in Section 2.1.4 will be utilized to determine the handling of the soil cuttings.

The test borings will be observed by a field engineer/geologist and a field log for each boring/monitoring well will be created. Real time air monitoring will be conducted while test borings are being completed using an OVM. Soil samples will be collected at two-foot intervals to the bottom of the boring for classification, laboratory analysis and screening with the OVM. Soil samples collected for analytical testing will typically be collected from contaminated soils or material, based on visual, olfactory, field screening (OVM) and engineering judgment that warrant further assessment. One soil sample will be collected for VOC analysis from each test boring. The soil sampling will be conducted utilizing the Soil Sampling FMG in Appendix A.

The monitoring wells will be developed to remove the fines and develop the sand filter pack utilizing the Well Development FMG in Appendix A. Hydraulic conductivity testing will be performed to assess whether the monitoring well is functioning and provide hydrologic information in accordance with the In Situ Hydraulic Conductivity (Slug Test) Procedure FMG in Appendix A.

Water level measurements will be collected from monitoring wells associated with Building 8 and existing wells from the GMCH Facility to interpret groundwater flow direction as outline in the Water Level Measurements FMG in Appendix A.

Groundwater samples will be collected from the four (4) newly installed monitoring wells and four (4) existing wells (MW-6-F-8, MW-8-003-B, MW-6-1 and MW-6-2). Groundwater sampling will be conducted utilizing low-flow sampling techniques as outlined in the Groundwater Sampling FMG in Appendix A. A water quality meter, disposable polyethylene tubing and a variable speed peristaltic pump will be utilized during the monitoring and sampling.

Water generated during development and purging prior to sampling will be containerized until the analytical results of the groundwater samples are received. IDW will be managed as described in Section 2.1.4.

2.2.3 Soil Probes

GZA is proposing to complete 13 soil probes within Building 8 (see Figure 5). Six (6) soil probes will be completed in the southeastern portion of the building to delineate the extent of TCE contamination identified in soil boring 8-00503C. TCE was detected at 1,000 ppm in a soil sample from 8 to 10 feet below the building slab at this location. The six (6) soil probes will be complete approximately 15 feet away from this previous location (see Figure 3) to determine the potential extent of the TCE contamination present in the subsurface soil.

Four (4) soil probes will be completed in the northern central portion of the building to delineate the extent of arsenic contamination identified in soil boring 8-001-G. Arsenic was detected at 65.8 ppm in a soil sample from 2 to 4 feet below the building slab at this location. The four (4) soil probes will be complete approximately 15 feet away from this previous location (see Figure 3) to determine the potential extent of the arsenic contamination present in the subsurface soil.

Three (3) soil probes will also be completed in the western interior portion of Building 8 (see Figure 5). These soil probes will be completed for general site coverage as the facility wide investigation completed in 2007 did not assess the western portion of the building west of the Former Chromium Sump Area (AOI-18, see Figure 3).

The soil probes will be advanced into overburden soils utilizing direct push technology via a hydraulic hammer mounted on a truck or track mounted rig equipped with a 2-inch outer diameter by 48-inch long macrocore sampler. Soil probes will be advanced to refusal, which is anticipated to be about 8 to 10 feet below the building slab based on previous investigations in the northeastern portion of the building.

A field engineer/geologist will observe the soil probes and create a field log for each probe. Real time air monitoring will be conducted while soil probes are being completed using an OVM. Soil samples will be collected from the soil probes for classification, laboratory analysis, and screening with the OVM. Soil samples will be collected at two foot intervals to the bottom of the probes. Samples collected for analytical testing will typically be collected from contaminated soils or material, based on visual, olfactory, field screening and engineering judgment that warrant further analysis. If total organic vapors are not detected above 1 part per million (ppm) during the field screening at a probe location, no soil sample will submitted for VOC analysis. The soil probe investigation will be completed in accordance with the Drilling Techniques and Soil Boring FMGs included in Appendix A.

2.2.4 Fish and Wildlife Resources Impact Analysis

A fish and wildlife impact analysis that characterizes resources used to identify potential or actual impacts will be performed for the Site (Part 1 assessment – see NYSDEC Draft DER-10). If no fish or wildlife resources or ecological exposure pathways are identified, then this component of the work will be considered complete. If there is a potential for fish and wildlife impacts, then a plan will be developed to implement a preliminary ecological impact assessment (Part 2).

2.3 ENVIRONMENTAL ANALYTICAL TESTING PROGRAM

The environmental testing program is summarized in Table 1. The location for sample collection will be determined based upon the results of the field screening and engineering judgment. The samples collected as part of this RI will be subject to analytical testing methodologies that follow NYSDEC Analytical Service Protocol (ASP) Category B deliverables and data validation. Further information regarding sampling and testing methodologies can be found in the QAPP (see Section 4.0).

Samples submitted for analytical testing will be given a unique sample designation. The sample designation will be done in accordance with the Sample Handling and Shipping FMG included in Appendix A.

Upon receipt of validated analytical results, a facility wide VOC isoconcentration map will be developed utilizing data collected from the RI and other program sampling (i.e., Delphi Harrison Thermal System Inactive Hazardous Waste Registry Site and Major Oil Storage Facility License) completed at the facility.

2.4 SURVEY

The survey will be done after completion of the fieldwork to locate soil probes and monitoring wells. This will allow measurement of the actual exploration locations and elevations.

A licensed land surveyor will be subcontracted to do the survey. Vertical measurements will include a ground surface elevation, plus top of casing and top of riser for monitoring wells. The top of riser will serve as the water level monitoring point. Vertical measurements will be made relative to the National Geodetic Vertical Datum (NGVD). Monitoring point measurements and top of protective casing measurements will be accurate to within 0.01 foot. Horizontal measurements and ground surface elevations will be accurate to within 0.1 foot.

The base map for the Site will include pertinent Site features and the investigation exploration locations.

2.5 SUBSURFACE SEWER ASSESSMENT

A subsurface sewer assessment will be completed for Building 8. The assessment will include providing drawings that identify the locations of the subsurface sewers present within the Building 8 BCP footprint. A storm sewer system drawing will also be provided that will identify the storm sewer system piping and outfall locations for the entire facility. The storm sewer system is currently sampled quarterly (SPDES Permit # NY 000 0558) and submitted to NYSDEC in a Discharge Monitoring Report (DMR). Analytical data has been collected from the storm system since February 1990. Appendix B contains the storm water parameter list and monitoring frequency requirements dating back to March 1989.

3.0 ADDITIONAL FIELD EXPLORATIONS

If determined to be necessary, contingent field explorations may be conducted. This work may consist of additional soil probes and monitoring well installations for supplemental soil and groundwater data to complement or fill in data gaps from the initial RI, if deemed necessary. If needed, a scope of work will be developed for review by NYSDEC prior to starting additional investigation activities. The work activities will be completed according to the procedures described in this RIWP and any subsequently approved modifications.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The Quality Assurance and Quality Control (QA/QC) for the Building 8 RI are discussed in the "GM Components Holdings, LLC, Brownfield Cleanup Program, Quality Assurance and Quality Control Plan, Building 7 (Site ID #C932138), Building 8 (Site ID #932139) and Building 10 (Site ID #C932140), Lockport Facility, 200 Upper Mountain Road, Lockport, New York" dated June 2010. The QA/QC Plan presents the objectives and specific QA/QC procedures associated with the RI activities planned for Building 8. Protocols for sample collection, sample handling and storage, Chain of Custody procedures, and laboratory and field analyses are described or specifically referenced to related investigation documents.

5.0 HEALTH AND SAFETY PROTOCOLS

The health and safety protocols for the Building 8 RI are discussed in the "Site Health and Safety Plan, GM Components Holdings, LLC, Brownfield Cleanup Program, Building 7 (Site ID #C932138), Building 8 (Site ID #932139) and Building 10 (Site ID #C932140), Lockport Facility, 200 Upper Mountain Road, Lockport, New York" dated April 20, 2010. The Health and Safety Plan presents the specific health and safety protocols associated with the RI activities planned for Building 8.

6.0 SCHEDULE

The following schedule is associated with the Building 8 field activities and RI report preparation.

Submit Revised Building 8 RI Work Plans:	October 26, 2010
Perform Building 8 RI: (Timing depends on coordinating subsurface investigations with manufacturing activities)	November through December 2010
Submittal of RI Report:	April 2011
Submittal of Alternative Analysis Report:	August 2011

7.0 CITIZEN PARTICIPATION

The Citizen Participation (CP) proponent for the Building 8 RI are discussed in the "Brownfield Cleanup Program, Citizen Participation Plans, GM Components Holdings, LLC, Building 7 Site ID #C932138, Building 8 Site ID #932139 and Building 10 Site ID #C932140, 200 Upper Mountain Road, City of Lockport, New York" dated June 2010. That CP Plan outlines how members of the affected and interested public are provided with information about how NYSDEC will inform and involve them during the investigation and remediation of the Site. Information such as project contacts, document repositories, site contact lists and CP activities are provided in the CP Plan.

TABLE

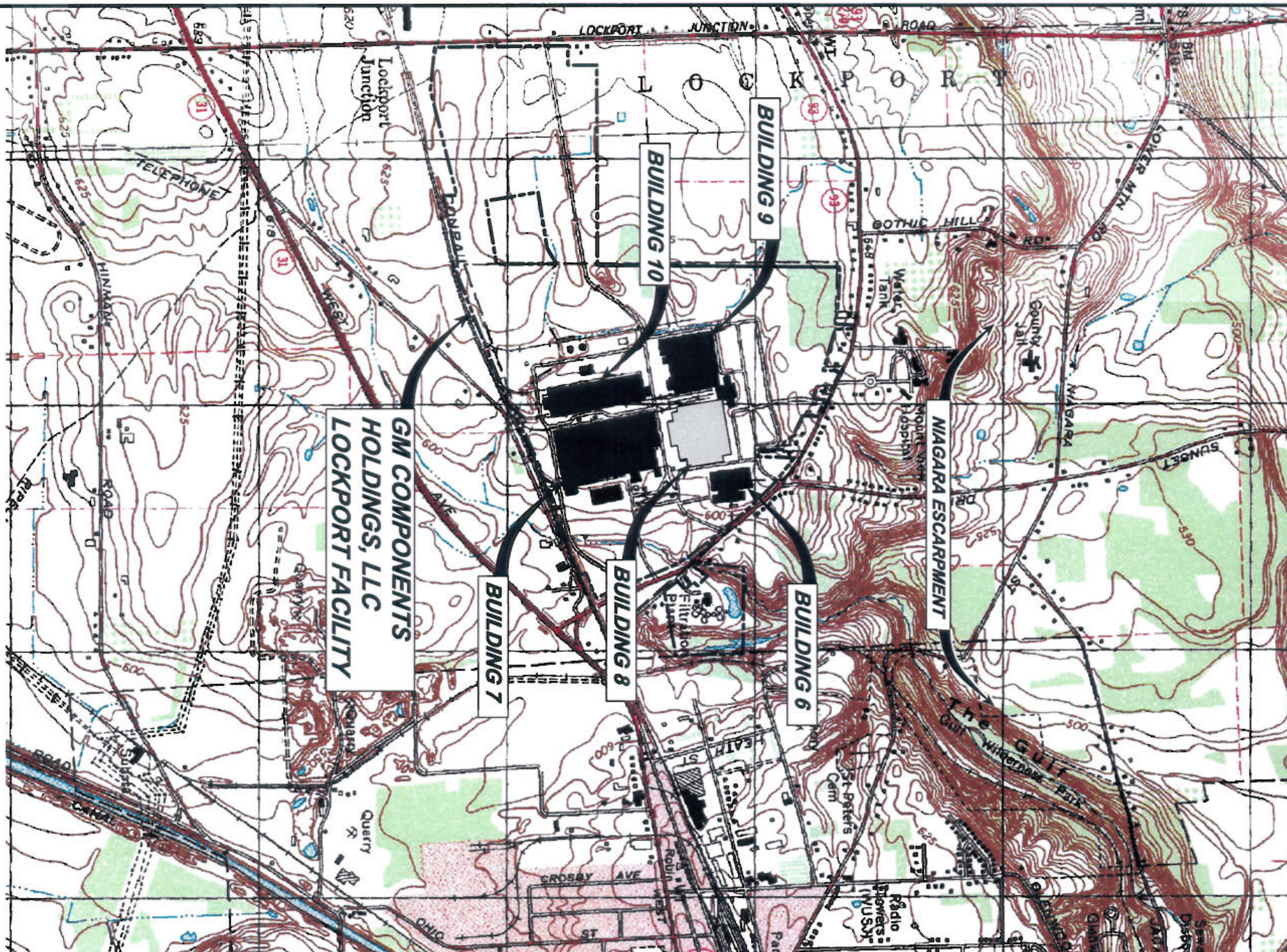
Table 1
Proposed Analytical Testing Program Summary
Building 8 Remedial Investigation Work Plan
GM Components Holdings
Lockport, New York

Location	Matrix	TCL VOCs	TCL SVOCs	TAL Metals	TCL PCBs	TO-15 VOCs
Subsurface Soil Samples						
Various[1]	Soil	17	7	7	7	0
Duplicate	Soil	1	1	1	1	0
MS/MSD	Soil	2	2	2	2	0
Rinsate	Water	1	1	1	1	-
Total		21	11	11	11	0
Monitoring Well Groundwater Samples						
Monitoring Wells	Groundwater	8	0	0	0	0
Duplicate	Groundwater	1	0	0	0	0
MS/MSD	Groundwater	2	0	0	0	0
Rinsate	Water	1	0	0	0	0
Trip Blank	Water	1	-	-	-	-
Total		13	0	0	0	0
Air Samples						
Indoor Air	Air	0	0	0	0	5
Sub-slab Air	Air	0	0	0	0	5
Outdoor Air	Air	0	0	0	0	1
Duplicate	Air	0	0	0	0	1
MS/MSD	Air	0	0	0	0	2
Total		0	0	0	0	14
	TOTAL	34	11	11	11	14

Notes:
1) Actual sample location to be selected based on field observation.
MS/MSD - Matrix Spike/Matrix Spike Duplicate.
TCL VOCs - Target Compound List Volatile Organic Compounds.
TCL SVOCs - Target Compound List Semi-volatile Organic Compounds.
TAL Metals - Target Analyte List Metals.
TCL PCBs - Target Compound List Polychlorinated Biphenyls.

FIGURES

 GZA-T:\PROJECTS\56500s\56546 GM Component LLC\BCP Work Plans\Building 8\FIGURE 1 LOCUS PLAN.dwg [Figure 1] October 26, 2010 - 3:22pm michael.kress



NOTE:
BASE MAP ADAPTED FROM U.S.G.S. TOPOGRAPHIC MAPS DOWNLOADED FROM TERRASERVER.MICROSOFT.COM

NORTH

DRAWN BY:	DEW
DATE:	OCTOBER 2010

GZA GeoEnvironmental of New York

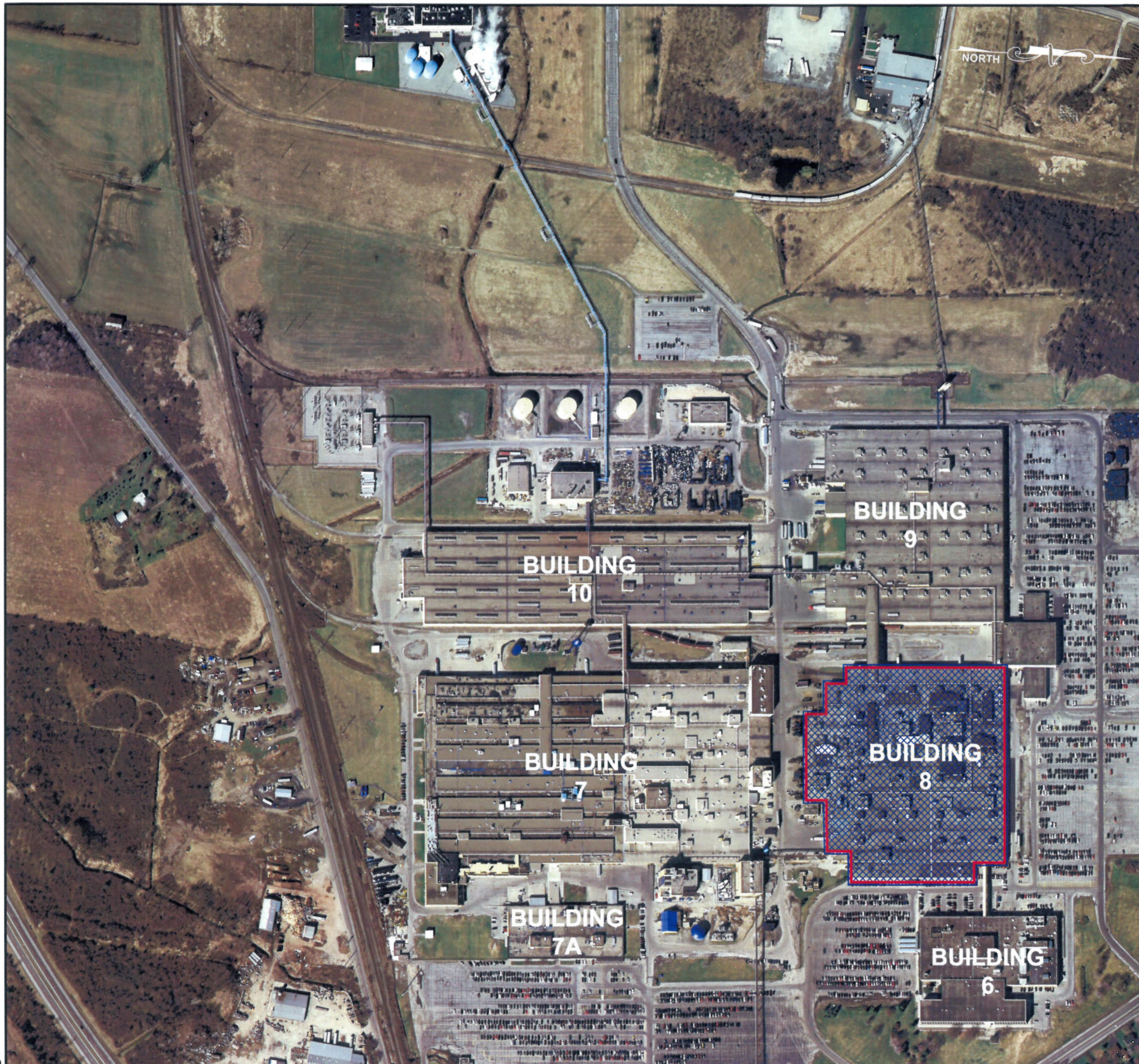
SCALE IN FEET
0 1000 2000 4000

GM COMPONENTS HOLDINGS, LLC
LOCKPORT FACILITY
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK
BROWNFIELD CLEANUP PROGRAM WORK PLAN
BUILDING 8 SITE ID# 932139

LOCUS PLAN

PROJECT No. **21.0056546.00**

FIGURE No. **1**



LEGEND:

INDICATES BUILDING 8 FOOTPRINT

SHADING INDICATES AREA ASSOCIATED WITH BUILDING 8 BCP SITE

NOTES:

1. BASE MAP ADAPTED FROM A 2005 AERIAL PHOTOGRAPH DOWNLOADED FROM http://www.nysgis.state.ny.us/gateway/mg/interactive_main.html AND SITE OBSERVATIONS.

2. THE SIZE AND LOCATION OF EXISTING SITE FEATURES SHOULD BE CONSIDERED APPROXIMATE.

DRAWN BY: DEW

DATE: OCTOBER 2010

GZA GeoEnvironmental of New York

APPROXIMATE SCALE IN FEET

0 200 400 800

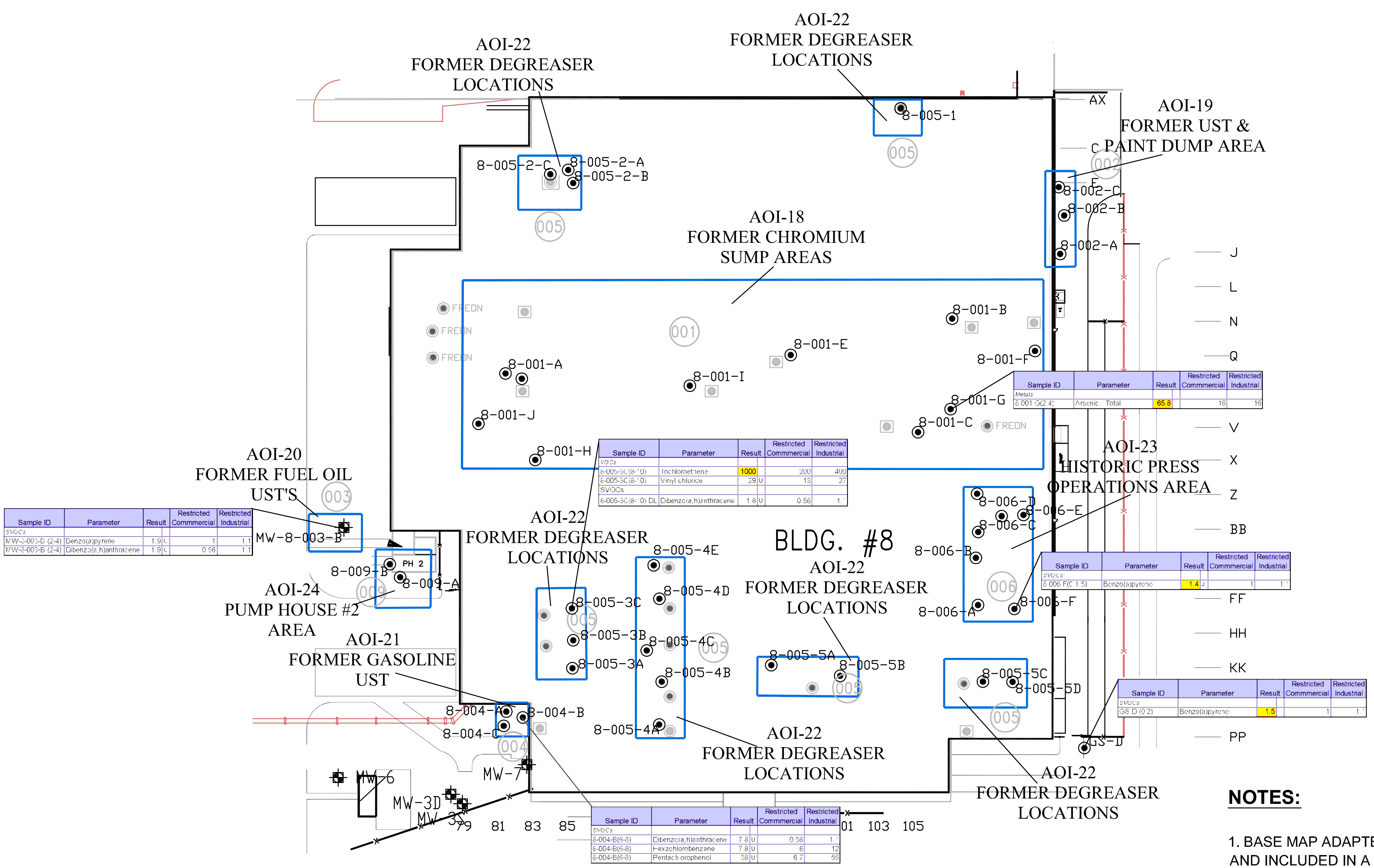
GM COMPONENTS HOLDINGS, LLC
LOCKPORT FACILITY
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK
BROWNFIELD CLEANUP PROGRAM WORK PLAN
BUILDING 8 SITE ID# 932139

SITE PLAN

PROJECT No.
21.0056546.00

FIGURE No.
2

GZA-T:\PROJECTS\56500s\56546 GM Component LLC\BCP Work Plans\Building 8\FIGURES 2-3.dwg [FIGURE 2] October 26, 2010 - 3:24pm michael.kress



Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
Metals					
8-001-G(2-4)	Arsenic, Total	65.8		16	16

Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
VOCs					
8-005-3C(8-10)	Trichloroethene	1000		200	400
8-005-3C(8-10)	Vinyl chloride	29	U	13	27
SVOCs					
8-005-3C(8-10) DL	Dibenzo(a,h)anthracene	1.8	U	0.56	1.1

Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
SVOCs					
MW-8-003-B (2-4)	Benzo(a)pyrene	1.9	U	1	1.1
MW-8-003-B (2-4)	Dibenzo(a,h)anthracene	1.9	U	0.56	1.1

Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
SVOCs					
8-006-F(0-1.5)	Benzo(a)pyrene	1.4	J	1	1.1

Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
SVOCs					
GS-D (0-2)	Benzo(a)pyrene	1.5		1	1.1

Sample ID	Parameter	Result		Restricted Commmercial	Restricted Industrial
SVOCs					
8-004-B(6-8)	Dibenzo(a,h)anthracene	7.8	U	0.56	1.1
8-004-B(6-8)	Hexachlorobenzene	7.8	U	6	12
8-004-B(6-8)	Pentachlorophenol	38	U	6.7	55

LEGEND:

- AREA OF INTEREST ID NUMBER OR LETTER
- AREA OF INTEREST
- BORINGS UNLESS NOTED
- FORMER CHROME SUMP
- FORMER DEGREASER LOCATIONS
- FORMER DEGREASER WITH SEPARATOR PIT
- MONITORING WELL
- 1.1 RESULT EXCEEDED SCREENING CRITERIA

NOTES:

1. BASE MAP ADAPTED FROM A FIGURE PREPARED BY ERM AND INCLUDED IN A 2007 FIELD INVESTIGATION REPORT.

2. RESULTS ARE IN MG/KG

U - INDICATES COMPOUND WAS ANALYZED FOR, BUT NOT DETECTED AT OR ABOVE REPORTING LIMIT. HOWEVER ONLY RESULTS REPORTED AS A "NONDETECT" THAT HAVE A REPORTING LIMIT 25% ABOVE THE UNRESTRICTED CRITERIA ARE SHOWN.

B - INDICATES THAT THE ANALYTE WAS FOUND IN THE ASSOCIATED BLANK, AS WELL AS IN THE SAMPLE

J - INDICATES AN ESTIMATED VALUE.

D - INDICATES COMPOUNDS IDENTIFIED IN AN ANALYSIS AT A SECONDARY DILUTION FACTOR

DRAWN BY: DEW

DATE: OCTOBER 2010

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APPROXIMATE SCALE IN FEET: 0 100 200 400

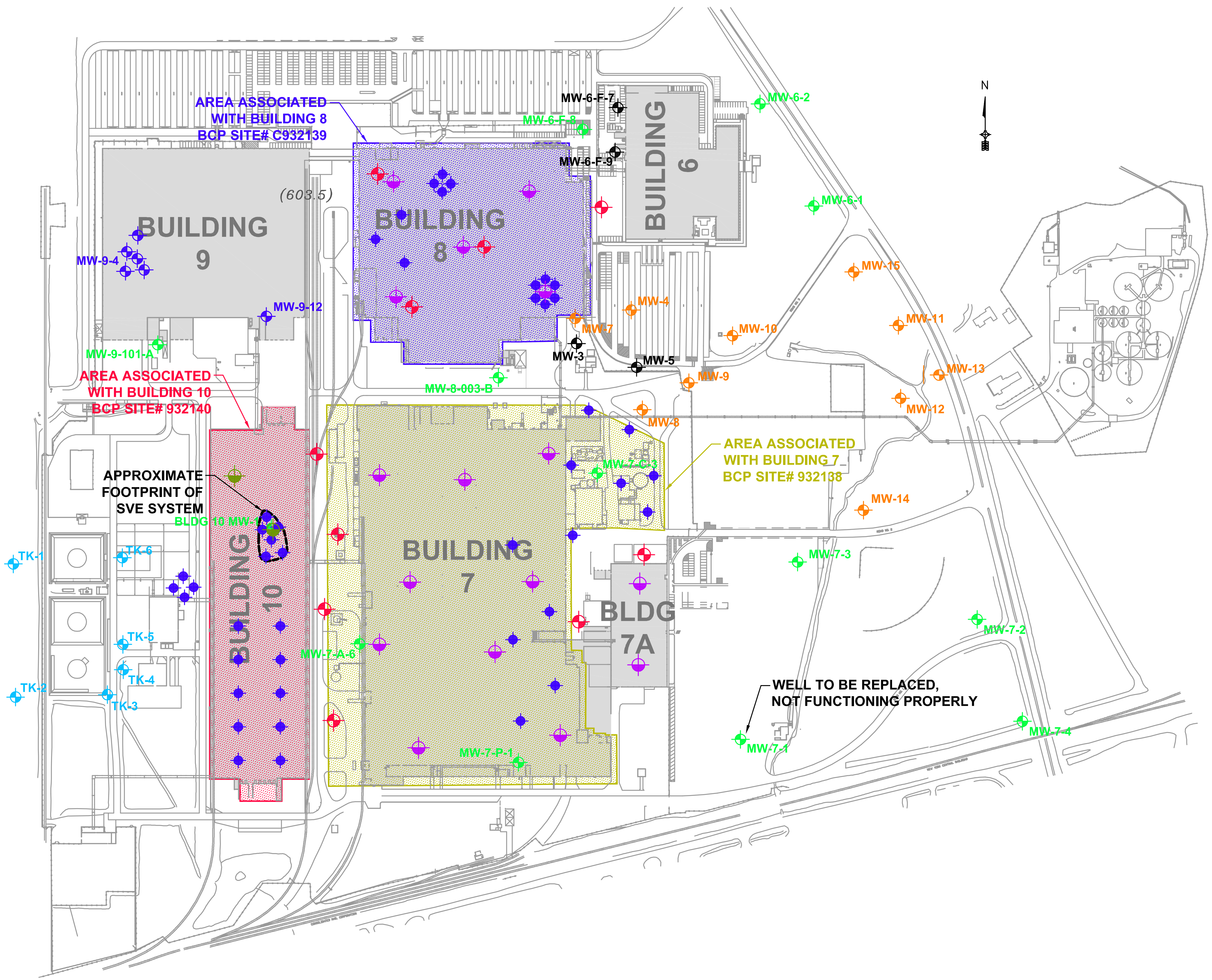
GM COMPONENTS HOLDINGS, LLC
LOCKPORT FACILITY
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK

BROWNFIELD CLEANUP PROGRAM WORK PLAN
BUILDING 8 SITE ID# 932139
PREVIOUSLY IDENTIFIED AREAS OF INTEREST

PROJECT No. 21.0056546.00

FIGURE No. 3

GZA-T:\PROJECTS\56500s\56546 GM Component LLC\BCP Work Plans\Building 8\FIGURES 2-3.dwg [FIGURE 3] October 26, 2010 - 3:26pm michael.kress



LEGEND:

- APPROXIMATE LOCATION OF PROPOSED BEDROCK MONITORING WELLS TO BE INSTALLED AND SAMPLED AS PART OF THE BCP INVESTIGATION (10 LOCATIONS)
- APPROXIMATE LOCATION OF PROPOSED SOIL PROBES TO BE COMPLETED AS PART OF THE BCP INVESTIGATION (45 LOCATIONS)
- APPROXIMATE LOCATION OF PROPOSED INTERIOR AIR AND SUB-SLAB SAMPLES (16 LOCATIONS)
- APPROXIMATE LOCATION OF PROPOSED INTERIOR AIR SAMPLES ONLY (2 LOCATIONS)
- MW-3 — APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS
- MW-15 — APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS SAMPLED AS PART OF THE ANNUAL MNA MONITORING IN APRIL 2010 (10 LOCATIONS)
- MW-7-3 — APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS TO BE SAMPLED AS PART OF THE BCP INVESTIGATION (13 LOCATIONS)
- TK-1 — APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS SAMPLED AS PART OF THE MOSF MONITORING REQUIREMENTS IN MAY 2010 (6 LOCATIONS)
- MW-9-4 — APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS TO BE ASSESSED AS PART OF THE BUILDING 9 SPILL ASSESSMENT (5 LOCATIONS)

NOTES:

1. BASE MAP ADAPTED FROM A DRAWING PROVIDED BY DELPHI THERMAL AND INTERIOR SYSTEMS SEPT. 2007.

2. THE SIZE AND LOCATION OF EXISTING SITE FEATURES SHOULD BE CONSIDERED APPROXIMATE.

DRAWN BY: DEW

DATE: OCTOBER 2010

GZA GeoEnvironmental of New York

APPROXIMATE SCALE IN FEET

0 200 400 800

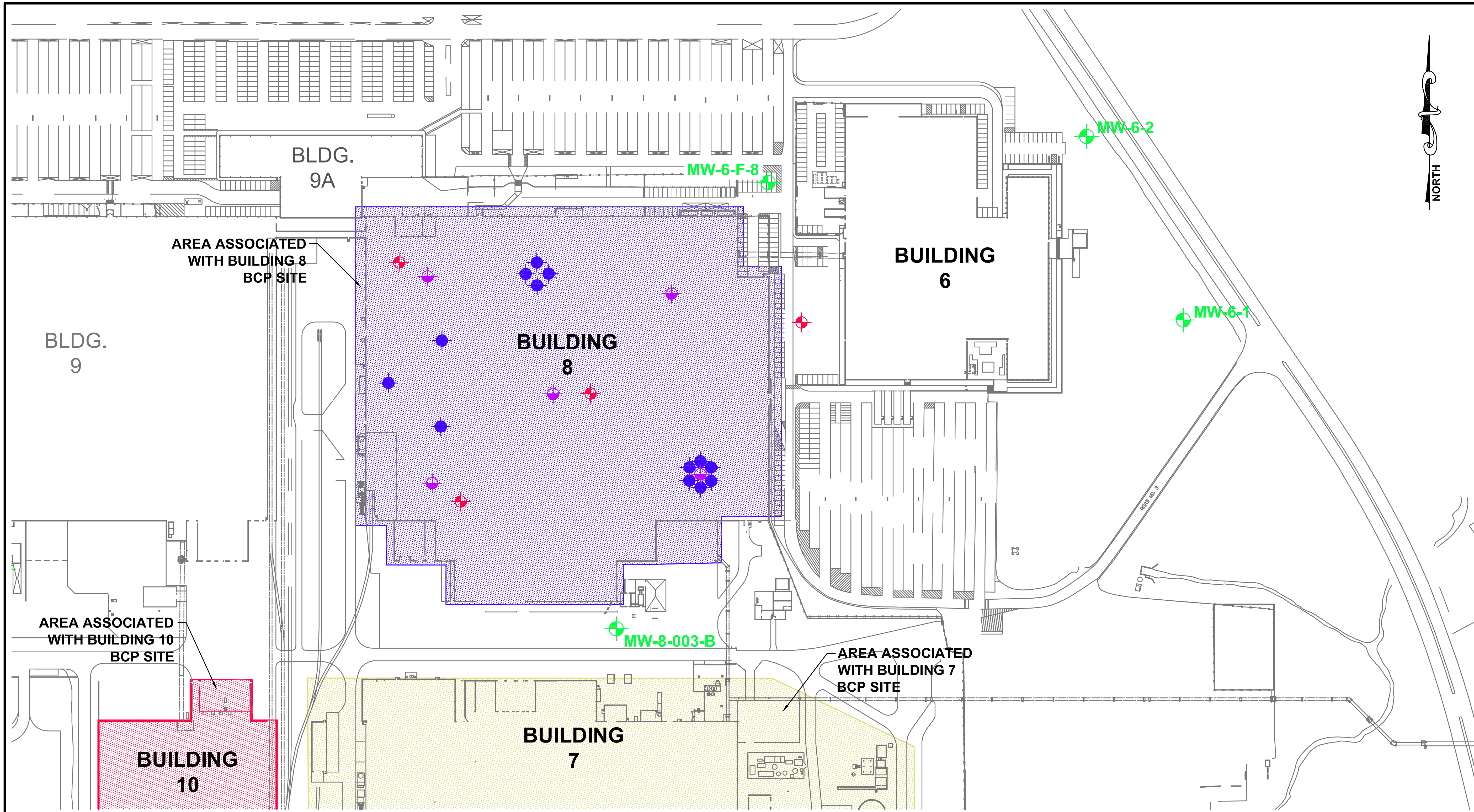
GM COMPONENTS HOLDINGS, LLC
LOCKPORT FACILITY
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK

BROWNFIELD CLEANUP PROGRAM WORK PLAN
BUILDING 8 SITE ID# 932139
BCP SITES & SITE-WIDE INVESTIGATION PLAN

PROJECT No.
21.0056546.00

FIGURE No.
4

GZA-T:\PROJECTS\56500s\56546 GM Component LLC\BCP Work Plans\Building 8\Figure 4 BCP Inv Plan.dwg [FIGURE 4] October 26, 2010 – 3:27pm michael.kress



LEGEND:

- APPROXIMATE LOCATION OF PROPOSED BEDROCK MONITORING WELLS TO BE INSTALLED AND SAMPLED AS PART OF THE BCP INVESTIGATION (4 LOCATIONS)
- APPROXIMATE LOCATION OF PROPOSED SOIL PROBES TO BE COMPLETED AS PART OF THE BCP INVESTIGATION (13 LOCATIONS)
- APPROXIMATE LOCATION OF PROPOSED INTERIOR AIR AND SUB-SLAB SAMPLES (5 LOCATIONS)
- MW-6-1 APPROXIMATE LOCATION AND DESIGNATION OF EXISTING MONITORING WELLS TO BE SAMPLED AS PART OF THE BCP INVESTIGATION (4 LOCATIONS)

NOTES:

1. BASE MAP ADAPTED FROM A DRAWING PROVIDED BY DELPHI THERMAL AND INTERIOR SYSTEMS SEPT. 2007.

2. THE SIZE AND LOCATION OF EXISTING SITE FEATURES SHOULD BE CONSIDERED APPROXIMATE.

DRAWN BY: DEW

DATE: OCTOBER 2010

GZA GeoEnvironmental of New York

APPROXIMATE SCALE IN FEET

0 100 200 400

GM COMPONENTS HOLDINGS, LLC
LOCKPORT FACILITY
200 UPPER MOUNTAIN ROAD
LOCKPORT, NEW YORK
BROWNFIELD CLEANUP PROGRAM WORK PLAN
BUILDING 8 SITE ID# 932139

PROPOSED EXPLORATION PLAN

PROJECT No.
21.0056546.00

FIGURE No.
5

APPENDIX A

FIELD METHOD GUIDES

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Disposal of Wash Solutions and Contaminated Equipment

All contaminated wash water, rinsates, solids and materials used in the decontamination process that cannot be effectively decontaminated (such as polyethylene sheeting) will be containerized and disposed of in accordance with applicable regulations and GM requirements. All containers will be labeled with an indelible marker as to contents and date of placement in the container, and any appropriate stickers required (such as PCBs).

Sampling of containerized wastes will be performed immediately upon completion of the investigations to minimize storage time on site. Storage of decontamination wastes on site will not exceed 90 days under any circumstances.

EQUIPMENT/MATERIALS

Decontamination equipment and solutions are generally selected based on ease of decontamination and disposability.

- Polyethylene sheeting.
- Metal racks to hold decontaminated equipment.
- Soft-bristle scrub brushes or long-handle brushes for removing gross contamination and scrubbing with wash solutions.
- Large galvanized wash tubs, stock tanks, or wading pools for wash and rinse solutions.
- Plastic buckets or garden sprayers for rinse solutions.
- Large plastic garbage cans or other similar containers lined with plastic bags can be used to store contaminated clothing.
- Contaminated liquids and solids should be segregated and containerized in DOT-approved plastic or metal drums, appropriate for off-site shipping/disposal if necessary.

REFERENCES

ASTM D5088 - Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites.

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WASTE CHARACTERIZATION

INTRODUCTION

The following procedure describes the techniques for characterization of investigation derived waste (IDW) for disposal purposes.

PROCEDURAL GUIDELINES

IDW may consist of soil cuttings (augering, boring, well installation soils, test pit soils), rock core or rock flour (from coring, reaming operations), groundwater (from well development, purging, and sampling activities), decontamination fluids, personal protective equipment (spent gloves, tyveks), (PPE), and disposal equipment (DE).

This procedure applies when disposition of investigation soils and/or groundwater is required in accordance with the project Work Plan. Generally, this procedure is applicable to Facilities where the Project Manager has assessed the areas of investigation and has developed a waste handling plan. In some areas and/or sections within a Facility it is permitted to return soil cuttings/test pit soils and groundwater to the source area (RCRA guidance allows waste management techniques within an area of concern without 'triggering' new points of waste generation). In other areas it may not be practical to return cutting/soils to their origin, and are better handled by this characterization/disposal procedure. These practice is consistent with USEPA procedure for IDW at RCRA facilities and CERCLA sites (Reference 1, 2).

Typically investigative derived wastes are dealt with following "Best Management Practices"; and are not handled under RCRA regulations until proven to be listed and/or identified characteristically hazardous waste. Investigative soils and groundwater cannot be considered a listed waste (in most circumstances) due to the lack of generator knowledge concerning chemical source, chemical origin and timing of chemical introduction to the subsurface. Consequently, waste sampling and characterization is performed to determine if the wastes exhibit a characterization of hazardous waste. Once the waste characterization is complete RCRA regulations apply if determined hazardous, if determined to be non-hazardous solid wastes, best management practices apply.

The disposal of soil cuttings and/or purged groundwater must be reviewed on a case by case basis prior to initiation of field activities. Two scenarios typically exist:

i) Sufficient Facility and/or site information exists that allows investigative cutting and/or purged groundwater to be placed back into the borehole or spread on the ground surface; or discharged or in the case of purged water directly onto the ground surface - No disposal required.

ii) Site conditions warrant that all materials handled will be contained and disposed of.

DISPOSAL PROCEDURES

The following outlines the waste characterization procedures to be employed when IDW disposal is required.

Soil/Rock Cuttings

Soils removed from boring activities and well construction tasks (including, rock flour from bedrock coring) will be contained within an approved container, suitable for transportation and disposal.

- Once placed into the approved container, any free liquids (i.e., groundwater) will be poured off for disposal as waste fluids, or solidified within the approved container using a solidification agent such as speedy-dri (or equivalent). No free liquid as determined by the "paint filter test" shall be present.
- Contained soils will be screened for the presence of Volatile Organic Compounds (VOCs), using a photoionization detector (PID); this data will be logged for future reference.
- Once screened, full and closed the container will be labeled in accordance with the Facility labeling requirements and placed into the Facility container storage area. At a minimum the following information will be shown a each container label: date of filling/generation, Facility name, source of soils (i.e., borehole or well), and Facility contact. If necessary, the exterior of the container will be cleaned to remove any lose dirt/cuttings.
- Prior to container closure, representative samples from a percentage of the containers will be collected for waste characterization purposes and submitted to the project laboratory. The waste characterization sampling scheme will be dictated by the Work Plan and establish the volume of soils required for analysis (depending on parameters required), the number of containers considered representative, the homogenization procedure, volatile analysis collection procedure (if required) and preparation handling requirements. Typically at a location where an undetermined site-specific parameter group exists, sampling and analysis may consist of the full RCRA Waste Characterization (ignitability, corrosivity, reactivity, toxicity), or a subset of the above based upon data collected, historical information and generator knowledge.

Groundwater

Well construction development, purging and sampling groundwater which requires disposal will be contained. Containment may be performed in 55-gallon drums, tanks suitable for temporary storage (i.e., Nalgene or Facility provided tanks 500 to 1,000 gallons) or if large volumes of groundwater are anticipated, drilling "frac" tanks may be utilized (20,000 gallons ±), or tanker trailer (5,000 to 10.000 gallons ±). In all cases the container/tank used for groundwater storage must be clean before use such that cross-contamination does not occur.

Decontamination Waters/Decontamination Fluids

- Decontamination waters and/or fluids will be segregated, contained, and disposed of accordingly.
- Decontamination waters may be disposed of with the contained groundwater once analytical results have been acquired. Depending on the extent of chemistry present it may be appropriate to discharge the decontamination waters to the Publicly Owned Treatment Works (POTW); or discharge to an on-site treatment system; or send off site for treatment. (Proper permitting may be required.)
- Spent Solvent/Acid Rinses - Solvents and acids used during decontamination activities must be segregated and disposed separately from the groundwater/decontamination water. Often if only small amounts of solvents are involved these can be left to evaporate. If large volumes are involved then containerization, labeling, and storage is required.

PPE/DE

- A number of disposal options exists for spent PPE/DE generated from investigation tasks. The options typically employed are:
  - i) Immediately disposed of within on-site dumpster/municipal trash; or
  - ii) If known to be contaminated with RCRA hazardous waste, disposed of off site at a RCRA Subtitle C facility; or alternatively PPE/DE decontaminated and disposed of on site within dumpster/municipal trash; or
  - iii) Contained and stored until the final remedy is implemented.

WASTE CHARACTERIZATION PROCEDURES

The Work Plan will identify the appropriate sampling strategy and analytes required to determine the IDW characteristics and disposal requirements. USEPA SW-846 (Reference 5, Chapters 9 and 10) describes the rationale for sampling plan development and sampling procedures. Generally random sampling and preparation of a composite sample of the media is employed for most investigative programs. The "GM Statistical Guidance – 2nd Edition" (Reference 4, Section 2.5) outlines the statistical rationale and approaches applicable to one-time waste streams. Often a minimum of four representative samples are required to gain valid waste characteristic data to determine the disposal option applicable (if statistics are employed).

Sampling procedures for IDW are:

- Solid Wastes - Grab sampling using precleaned sample spoons from bulk piles, lugger boxes, or as drums are being filled is commonly employed. In some instances sufficient media mixing may be evident to permit drum sampling from a random number of drums by accessing only the top solids. In other instances where stratification is evident, a sample trier/hand auger or device to collect from the entire vertical profile is required. Typically, a composite sample(s) from representative areas of the container(s) is homogenized and submitted for analysis. If VOCs are being evaluated, compositing and homogenization is not permitted. Individual grab samples are typically required for VOCs.
- Waste Waters - Grab sampling techniques using precleaned bailers or sampling pumps are typically employed. Waters in bulk are typically sampled once using a bailer or pump. The Work Plan will outline the appropriate sample frequency and analytes necessary to adequately characterize the contained waters. Facility sewer discharge permit parameters will be evaluated when disposal to the POTW is being considered.

  Note: If NAPL is present special sampling and handling requirements will apply. Precautions to separate the NAPL from the wastewater will commonly be employed, due to the special material handling and waste disposal requirements when dealing with phase materials.
- Spent Solvent/Acid Rinses - The need for sampling must be determined in consultation with the waste management organization handling the materials. If known that only the solvent and/or acids are present, then direct disposal/treatment using media specific options maybe possible without sampling (i.e., incineration).
- PPE/DE - Typically not sampled and included with the disposal of the solid wastes.

EQUIPMENT/MATERIALS

- Sample spoons, trier, auger.
- Sample mixing bowl.
- Sampling bailer, or pump.
- Sample glassware.

REFERENCES

USEPA RCRA - Guidance and Policies: Management of Remediation Waste Under RCRA (October 1998).

USEPA RCRA - Management of Contaminated Media (October 1998).

USEPA CERCLA Guidance (Options Relevant to RCRA Facilities): Guide to Management of Investigation-Derived Wastes (January 1992).

2nd Edition - GM Statistical Guidance Section 2.5.1. Solid Waste Characterization Subsection 2.5.1.1. One-Time Waste Stream Characterization (Date Required).

USEPA Office of Solid Waste - SW-846 Chapter 9 Sampling Plan, Chapter 10 Sampling Methods (September 1986).

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REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 2.3
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS LLC	
REVISION NO.: 0	REVISION DATE:

SOIL BORINGS

INTRODUCTION

The following presents a description of the methods generally employed for the installation of boreholes and the collection of subsurface soil samples. Boreholes are typically installed to define geologic conditions for hydrogeologic and geotechnical evaluation; to allow the installation of monitoring wells and piezometers; and to allow the collection of subsurface soil samples (generally above the water table) for chemical analysis.

Several manual methods are available for the collection of shallow subsurface soil samples (e.g., hand augers, post-hole augers, vibratory hammers). However, the most common methods used by GM to advance boreholes are rotosonic drilling techniques, hollow-stem augers (HSA), or the use of a direct-push equipment. Rotosonic drilling and direct-push techniques are preferred boring approaches at GM Facilities. FMG 2.2 - Drilling Techniques, provides insight into the advantages/disadvantages of these drilling methods.

PROCEDURES REFERENCED

- FMG 1.3 - Utility Clearance.
- FMG 2.2 - Drilling Techniques.
- FMG 2.6 - Soil Classification.
- FMG 2.7 - Rock Classification.
- FMG 6.1 - Soil.

PROCEDURAL GUIDELINES

The following activities must be undertaken prior to undertaking a borehole installation and subsurface soil sampling program.

i) Assemble all equipment and supplies required per the Work Plan.

ii) Obtain a site plan and any previous stratigraphic logs. Determine the exact number and location of boreholes to be installed and the depths of samples for chemical analysis.

iii) Contact the analytical group to arrange/determine:

   - Laboratory;
   - Glassware/sample jars;
   - Cooler;
   - Shipping details;
   - Start date; and
   - Expected duration.

iv) Establish borehole locations in field using available landmark or by surveying methods if necessary.

v) Arrange for utility clearance of franchised utilities and site utilities.

vi) Determine notification needs with the Project Manager. Have the regulatory groups, landowner, GM Facility personnel, and laboratory been informed of the sampling event?

vii) Determine the methods for handling and disposal of drill cuttings, wash waters, and spent decontamination fluids.

Once the prior planning and preparation activities are completed, the borehole installation and subsurface soil sampling program can proceed. The typical series of events which takes place is:

- Locating and marking of borehole locations (if not already completed).
- Equipment decontamination.
- Final visual examination of proposed drilling area for utility conflicts/final hand auger or post-hole check to verify utility absence.
- Advancement of borehole and collection of the soil sample.
- Field screening of soil sample.
- Description of soil sample. (Form FMG 2.6-01 - Stratigraphy Log - Overburden (Page 1/Page 2) will be used to record data.)
- Sample preparation and packaging.
- Abandonment of boreholes.
- Surveying of borehole locations and elevations.
- Field note completion and review.

i) Locating and Marking of Boreholes/Final Visual Check

The proposed borehole locations marked on the site plan are located in the field and staked. On most sites, this will likely be done several days in advance of the drill rig arriving on site. Unless boreholes are to be installed on a fixed grid, the proposed locations are usually strategically placed to assess site conditions.

Once the final location for the proposed boring has been selected and utility clearances are complete, one last visual check of the immediate area should be performed before drilling proceeds. This last visual check should confirm the locations of any adjacent utilities (subsurface or overhead) and verification of adequate clearance. If gravity sewers or conduits exist in the area, any access manholes or chambers should be opened and the conduit/sewer alignments confirmed. Do not enter manholes unless confined space procedures are followed.

ii) Borehole Advancement

If possible, it is prudent to use a hand auger or post-hole digging equipment to a sufficient depth to verify the absence of buried utilities and pipelines. This procedure should clear the area to the full diameter of the drilling equipment which will follow.

If it is necessary to relocate any proposed borehole due to terrain, utilities, access, etc., the Project Manager must be notified and an alternate location will be selected.

Prior to use and between each borehole location at an environmental site, the drilling and sampling equipment must be decontaminated. All decontamination must be conducted in accordance with the project-specific plans or the methods presented in FMG 9.0 - Equipment Decontamination.

The clean augers/tooling are covered with clean plastic sheeting to prevent contact with foreign materials. For geotechnical, geologic, or hydrogeologic studies where contaminants will not be present, it is sufficient to clean the drilling equipment simply by removing the excess soils.

Collection of soil samples is one of the most important considerations in selecting drilling methods. Therefore, the need for reviewing drilling techniques (FMG 2.2 - Drilling Techniques) and the Site objectives must first be considered. Soil Classification will be completed in accordance with FMG 2.6 - Soil Classification. Sections iii) and iv) describe borehole soil sampling procedures using direct-push tooling and HSA/split-spoon sampling (Standard Penetration Testing - SPT), respectively.

iii) Direct-Push/Macro-Core™ Soil Sampler

The operation of the direct-push/Macro-Core™ Soil Sampler (or equivalent) consists of "pushing" the sampler into the subsurface and then retrieving it using a direct-push soil probing machine. The collected soil core is contained within an internal soil liner (acetate, polyethylene, or teflon) and removed from the sampler once returned to the ground surface. Sampler length is variable depending on equipment available (2 feet, 4 feet, 5 feet). Once the soil liner has been removed and the outer sampler decontaminated, a new liner is inserted and the sampler reassembled. The clean sampler is then driven back down the same hole to collect the next soil sample.

The Macro-Core™ sampler can be used in either the open-tube or closed-point sampling mode. The open-core sample mode is most commonly used in stable soil conditions. In unstable soils, the piston rod point system prevents collapsed soil from entering the sampler as it is advanced back down the hole. Once at the sample depth, the piston rod is unthreaded and released. The sampler is then driven into the subsurface to fill the sampler with soil, the piston point rides on top of the soil, as it enters the sampler.

Once recovered the soil liner with collected soils is opened (cut lengthwise) and examined to collect soil screening information, soil logging information, and soils for chemical analysis.

iv) <u>Standard Penetration Testing (SPT) Sampling and Testing Procedure</u>

This method is used to obtain representative samples of subsurface soil materials and to determine a measure of the in situ relative density of the subsurface soils. The test methods described below must be followed to obtain accurate SPT values. The split spoon is typically driven in advance of an HSA string which allows collection of the disturbed but representative sample.

SPT sampling is performed by using a split barrel sampler in accordance with ASTM D1586. The split barrel sampler, or split spoon, consists of an 18- or 24-inch long, 2-inch outside diameter tube, which comes apart length wise into two halves. The split spoon is typically driven in advance of an HSA string which allows collection of the disturbed but representative soil sample.

Once the borehole is advanced to the target depth and the borehole cleaned of cuttings, representative soil samples are collected in the following manner:

- The split-spoon sampler should be inspected to ensure it is properly cleaned and decontaminated. The driving shoe (tip) should be relatively sharp and free of severe dents and distortions.
- The cleaned split-spoon sampler is attached to the drill rods and lowered into the borehole. Do not allow the sampler to drop onto the soil.
- After the sampler has been lowered to the bottom of the hole, it is given a single blow to seat it and make sure that it is in undisturbed soil. If there still appear to be excessive cuttings in the bottom of the borehole, remove the sampler from the borehole and remove the cuttings.
- Mark the drill rods in three or four successive 6-inch (0.15 m) increments, depending on sampler length, so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-inch (0.15 m) increment.

The sampler is then driven continuously for either 18 or 24 inches (0.45 or 0.60 m) by use of a 140-pound (63.5 kg) hammer. The hammer may be lifted and dropped by either the cathead and rope method, or by using a trip, automatic, or semi-automatic drop system. The hammer should free-fall a distance of 30 inches (±1 inches) (760 mm, ±25 mm) per blow. Measure the drop at least daily to ensure that the drop is correct. To ensure a free-falling hammer, no more than 2 1/4 turns of the rope may be wound around the cathead (see ASTM D1586). The number of blows applied in each 6-inch (0.15 m) increment is counted until one of the following occurs:

- A total of 50 blows have been applied during any one of the 6-inch (0.15 m) increments described above;
- A total of 100 blows have been applied;
- There is no advancement of the sampler during the application of ten successive blows of the hammer (i.e., the spoon is "bouncing" on a stone or bedrock); or
- The sampler has advanced the complete 18 or 24 inches (0.45 or 0.60 m) without the limiting blow counts occurring as described above.

In some cases where the limiting number of blow counts has been exceeded, the Consultant may direct the driller to attempt to drive the sampler more if collection of a greater sample length is essential.

On the field form, record the number of blows required to drive each 6-inch (0.15 m) increment of penetration. The first 6 inches is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches (0.15 m) of penetration is termed the "standard penetration resistance" or the "N-value".

Note: If the borehole has sloughed and there is caved material in the bottom, the split spoon may push through this under its own weight, but now the spoon is partially "pre-filled". When the spoon is driven the 18 or 24 inches representing its supposedly empty length, the spoon fills completely before the end of the drive interval. Two problems arise:

1. *the top part of the sample is not representative of the in-place soil at that depth; and*
2. *the SPT value will be artificially higher toward the bottom of the drive interval since the spoon was packed full. These conditions should be noted on the field log.*

The sampler is then removed from the borehole and unthreaded from the drill rods. The open shoe (cutting end) and head of the sampler are partially unthreaded by the drill crew and the sampler is transferred to the geologist/engineer work surface.

Note: A table made out of two sawhorses and a piece of plywood is appropriate, or a drum, both covered with plastic sheeting.

The open shoe and head are removed by hand, and the sampler is tapped so that the tube separates.

Note: Handle each split spoon with clean disposable gloves if environmental issues are being investigated.

Measure and record the length of sample recovered making sure to discount any sloughed material that is present on top of the sample core.

Caution must be used when conducting SPT sampling below the groundwater table, particularly in sand or silt soils. These soils tend to heave or "blow back" up the borehole due to the difference in hydraulic pressures between the inside of the HSA and the undisturbed soil. To equalize the hydraulic pressure, the inside of the HSA must be filled with water or drilling mud. The drilling fluid level within the boring or HSAs needs to be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling. Since heave or blow back is not always obvious to the driller, it is essential that the water level in the borehole always be maintained at or above the groundwater level.

Heaving conditions and the use of water or mud should be noted on the field logs.

SPT sampling below the water table in sands and silt occasionally results in low SPT values being obtained due to the heaving effect disturbing the soil especially if the water level in the hole has not been maintained at the in situ water level. Suspect low N values should be noted on the field logs. If it is critical to have accurate N values below the water table, other methods can be employed, such as conducting a dynamic cone penetration test. This quick and easy test involves attaching a cone shaped tip to the end of the drill rods, and driving the tip into the ground similar to the SPT method, except that the borehole is not pre-augered. Cones may be driven 20 to 40 feet through a formation without augering. Blow counts are recorded for each foot (0.3 m) of advancement.

A variation of split barrel sampling involves the use of a longer barrel in conjunction with HSAs. The sampling barrel is installed inside the auger with a swivel attachment to limit rotation of the barrel. After completion of a 5-foot auger penetration, the auger is left in place and the barrel retrieved from the borehole. The sampler should be handled and the sample retrieved in the same way as described above for SPT sampling.

Thin-Walled Samplers (Shelby Tubes)

Thin-walled samplers are used to collect relatively undisturbed samples (as compared to split-spoon samples) of soft to stiff clayey soils. Shelby tubes are commonly used. The Shelby Tube has an outside diameter of 2 or 3 inches and is 3 feet long. These undisturbed samples are used for certain laboratory tests of structural properties (consolidation, hydraulic conductivity, shear strength) or other tests that might be influenced by sample disturbance. Procedures for conducting thin-walled tube sampling are provided in ASTM D1587, and are briefly described below.

- The soil deposit being sampled must be cohesive in nature, and relatively free of sand, gravel, and cobble materials, as contact with these materials will damage the sampler.
- Clean out the borehole to the sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above groundwater level during the sampling operation.
- Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or HSA as carefully as possible to avoid disturbance of the material to be sampled.
- Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler into the formation without rotation by a continuous and relatively rapid motion; usually hydraulic pressure is applied to the top of the drill rods.
- Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.
- In no case should the length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 inches for cuttings.
- The tube may be rotated to shear the bottom of the sample 2 to 3 minutes after pressing in, and prior to retrieval to ensure the sample does not slide out of the tube. Lift the weight of the rods off of the tube prior to rotating.
- Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.
- Package and transport the sample in accordance with FMG 6.10 - Sample Handling and Shipping.

On occasion it maybe required to extract the sample from the tube in the field.

- A sample extruder, which consists of a clamp arrangement to hold the tube and a hydraulic ram to push the sample through the tube, is usually mounted on the side of the rig. To prevent cross-contamination, be certain that the extruder is field cleaned between each sample.
- The sample is then extruded into a carrying tray; these are often made from a piece of 4-inch or 6-inch diameter PVC pipe cut lengthwise. Be certain that the carrying tray is field cleaned between each sample. The sample is carried to the work station to describe the sample, trim the potentially cross contaminated exterior, and place it in the appropriate container.
- The Shelby tube may then be thoroughly field cleaned and decontaminated for reuse. Since they are thin-walled, the tubes are easily damaged, crimped, or otherwise distorted during handling or pushing. The Shelby tube should be inspected before use and any which are significantly damaged should be rejected.

v) Borehole Completion

At the completion of the soil boring, once the soil/groundwater samples have been collected, the borehole annulus is then abandoned. Borehole abandonment options are identified in FMG 2.5 - Borehole Abandonment/Sealing. Each boring will be surveyed to establish vertical/horizontal information; field ties (i.e., swing ties) will also be collected to document the boring location. Once completed, a stratigraphic log will be prepared for reporting purposes.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Form 2.6-01 - Stratigraphy Log - Overburden (Page 1/Page 2).
- Tape measure.

REFERENCES

ASTM D420-93 - Guide to Site Characterization for Engineering, Design, and Construction Purposes.

ASTM D1452-80 - Practice for Soil Investigation and Sampling by Auger Borings.

ASTM D1586-84 - Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D1587-94 - Practice for Thin-Walled Tube Geotechnical Sampling of Soils.

ASTM D2488-93 - Practice for Description and Identification of Soils (Visual-Manual Procedure).

EPA OSWER-9950.1,1986. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document.

National Water Well Association, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. 1989.

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SOIL CLASSIFICATION

INTRODUCTION

The stratigraphic log is a factual description of the soil at the borehole location and is relied upon to interpret the soil characteristics, and their influence and significance in the subsurface environment. The accuracy of the stratigraphic log is to be verified by the person responsible for interpreting subsurface conditions. An accurate description of the soil stratigraphy is essential for a reasonable understanding of the subsurface conditions. Confirmation of the field description by examination of representative soil samples by the project geologist, hydrogeologist, or geotechnical engineer (whenever practicable) is recommended.

The ability to describe and classify soil correctly is a skill that is learned from a person with experience and by systematic training and comparison of laboratory results to field descriptions.

It is GM's Policy to log soils according to the Unified Soil Classification System (USCS) described in the following.

PROCEDURES REFERENCED

- FMG 2.1 - Test Pits.
- FMG 2.3 - Soil Borings.

PROCEDURAL GUIDELINES

Several methods for classifying and describing soils or unconsolidated sediments are in relatively widespread use. The Unified Soil Classification System (USCS) is the most common. With the USCS, a soil is first classified according to whether it is predominantly coarse grained or fine grained.

The description of fill soil is similar to that of natural undisturbed soil except that it is identified as fill and not classified by USCS group, relative density, or consistency. Those logging soils must attempt to distinguish between soils that have been placed (i.e., fill) and not naturally present; or soils that have been naturally present but disturbed (i.e., disturbed native).

It is necessary to identify and group soil samples consistently to determine the subsurface pattern or changes and non-conformities in soil stratigraphy in the field at the time of drilling. The stratigraphy in each borehole during drilling is to be compared to the stratigraphy found at the previously completed boreholes to ensure that pattern or changes in soil stratigraphy are noted and that consistent terminology is used.

Visual examination, physical observations and manual tests (adapted from ASTM D2488, visual-manual procedures) are used to classify and group soil samples in the field and are summarized in this subsection. ASTM D2488 should be reviewed for detailed explanations of the procedures. Visual-manual procedures used for soil identification and classification include:

- Visual determination of grain size, soil gradation, and percentage fines.
- Dry strength, dilatancy, toughness, and plasticity (thread or ribbon test) tests for identification of inorganic fine grained soil (e.g., CL, CH, ML, or MH).
- Soil compressive strength and consistency estimates based on thumb indent and pocket penetrometer (preferred) methods.

The three main soil divisions are: coarse grained soil (e.g., sand and gravel), fine grained soil (e.g., silt and clay), and soil with high natural organic matter content (e.g., peat and marl).

Coarse Grained Soil

The USCS group symbols for coarse grained soil are primarily based on grain or particle size, grain size distribution (gradation), and percent fines (silt and clay content).

Coarse grained soils are then further subdivided according to the predominance of sand and gravel. Course grained soil is made up of more than 50 percent, by weight, sand size, or larger (75 μm diameter, No. 200 sieve size or larger). It is noted that there are other definitions for coarse grained or coarse textured soil and for sand size such as soil having greater than 70 percent particles equal to or greater than 50 μm diameter.

Descriptions for grain size distribution of soil include; poorly graded (i.e., soil having a uniform grain size, SP and GP) and well graded (i.e., poorly sorted; having wide range of particle sizes with substantial intermediate sizes, SW and GW).

Coarse grained soils are further classified based on the percentage of silt and clay it contains (fines content). Coarse grained soils containing greater than 12 percent fines is commonly described as dirty. This description arises from the soil particles that adhere when the soil is rubbed between the hands or adhere to the sides of the jar after shaking or rolling the soil in the jar. The jar shake test which results in segregation of the sand and gravel particles is also used as a visual aid in determining gravel and sand percentages.

Examples of the group symbol, name, and adjectives used to describe the primary, secondary, and minor components of soil are; GW - Sandy Gravel (e.g., 70 percent gravel and 30 percent sand) or Sandy Gravel trace silt (less than 10 percent silt), and SP - Sand, uniform.

Relative density is an important parameter in establishing the engineering properties and behavior of coarse grained soil. Relative density of non-cohesive (granular) soil is determined from standard penetration test (SPT) blow counts (N values) (after ASTM Method D1586).

The SPT gives a reliable indication of relative density in sand and fine gravel. N values in coarse grained soil are influenced by a number of factors that can result in overestimates of relative density (e.g., in coarse gravel and dilatent silty fine sand) and can be conservative and underestimate the relative density (e.g., sand below the groundwater table and uniform coarse sand). These effects will be assessed by the project geotechnical engineer, if required, and need not be taken into account by field personnel.

Other dynamic methods, such as modified SPT and cone penetration tests, are used on occasion to supplement or replace the SPT method for certain site-specific conditions. The details of all modifications to the SPT or substitute methods should be recorded as they are required to interpret test results and correlate to relative density.

Fine Grained Soil

A soil is fine grained if it is made up of half or more of clay and silt (i.e., fines greater than 50 percent by weight passing the 75 μm (No. 200) sieve size). A description of visual-manual field methods and criteria (after ASTM D2488) that are used to further characterize and group fine grained soil (e.g., CL, CH, ML, or MH) including dry strength, dilatancy, toughness, and plasticity (thread or ribbon test) follows. Fine grained soils are subdivided on a basis of the liquid limit and the degree of plasticity.

The accurate identification of silts and clays can be aided by the use of some single field tests. Clay is sticky, will smear readily, and can be rolled into a thin thread even when the moisture content is low. When it is dry clay forms hard lumps. Silt on the other hand, has a low dry strength, can be rolled into threads only at high moisture content, and a wet silt sample will puddle when it is tapped.

Criteria for Describing Dry Strength

Description	***Criteria***
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.

High	The dry specimen crumbles into powder with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Criteria for Describing Dilatency

Description	***Criteria***
None	No visible change in small wetted specimen when rapidly shaken in palm of hand.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing or stretching.

Criteria for Describing Toughness

Description	***Criteria***
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Plasticity

Description	***Criteria***
Nonplastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Examples of group symbol identification based on visual-manual procedures and criteria for describing fine grained soil are:

Group Symbol	*Dry Strength Plasticity*	*Dilatency*	*Toughness*
ML	None to low Slight	Slow to rapid	Low or thread cannot be formed
CL	Medium to high Low	None to slow	Medium
MH	Low to medium Low	None to slow	Low to medium
CH	High to very high High	None	High

A requirement for positive classification by USCS group symbols (as described in Test Method ASTM D2487) is laboratory determination of particle size characteristics, liquid limit and plasticity index. The need for this type of testing will be determined by the project geologist, hydrogeologist, or geotechnical engineer.

Examples of name terminology that accompanies the group symbols are ML - Sandy Silt (e.g., 30 percent sand) and CL - Lean Clay with sand (e.g., 15 to 29 percent sand).

The correlation between N value and consistency for clays is rather unreliable. It is preferable to determine consistency using more appropriate static test methods, particularly for very soft to stiff clay soil. N value estimates of consistency are more reasonable for hard clay.

Unconfined compressive strength (Su) may be estimated in the field from the pocket penetrometer test method. To obtain a pocket penetrometer estimate of consistency and compressive strength, the soil core is cut perpendicular to the core length, the length of core (minimum 4 inches) is held in the hand and a moderate confining pressure is applied to the core (not sufficient to deform the core); the penetrometer piston tip is slowly inserted into the perpendicular face of the core until the penetrometer indents into the soil core to the mark indicated on the tip of the penetrometer piston; the penetrometer estimate of soil compressive strength (Su) is the direct reading of the value mark on the graduated shaft (in tons per square foot or other unit of pressure as indicated) indicated by the shaft ring marker, or in some models, by the graduated piston reading at the shaft body. To obtain an average estimate, this procedure is completed several times on both ends and mid cross-section of the core. For Shelby tube (or thin wall sampler) samples the pocket penetrometer tip is applied to the exposed bottom of the sample at several locations.

Estimates of compressive strength for clay soil of very soft to stiff consistency are better established by in situ shear vane tests or other static test methods.

The description of consistency (or strength) is an important element in determining the engineering properties and strength characteristics of fine grained cohesive soil. Consistency terms (e.g., soft, hard) are based on the unconfined compressive strength (Su) and shear strength or cohesion (cu) of the soil.

The ease and pattern of soil vapor and groundwater movement in the subsurface is influenced by the natural structure of the soil. Soil structure, for the most part, depends on the deposition method and, to a lesser extent, climate.

Visual Appearance/Other Features

Those logging soils should also note the presence, depth and components of fill soils (if evident), and note the distinction between disturbed native soils (i.e., excavation likely performed) vs. undisturbed native soils.

Other features such as root presence/structure, and soil fractures should also be recorded. Soil fractures should be described noting fracture orientation (i.e., horizontal/vertical), length/aperture and appearance of soil infilling, oxidation and/or weathering (if present).

Field Sample Screening

Upon the collection of soil samples, the soil is screened with a photoionization detector (PID) for the presence of organic vapor. This is accomplished by running the PID across the soil sample. Record the highest reading and sustained readings.

Note:	*The PID measurement must be done upwind of the excavating equipment or any running engines so that exhaust fumes will not affect the measurements.*

Another method of field screening is head space measurements. This consists of placing a portion of the soil sample in a sealable glass jar, placing aluminum foil over the jar top, and tightening the lid. Alternatively, plastic sealable bags maybe utilized for field screen in lieu of glass containers. The jar should only be partially filled. Shake the jar and set aside for at least 30 minutes. After the sample has equilibrated, the lid of the jar can be opened; the foil is punctured with the PID probe and the air (headspace) above the soil sample is monitored. Record this headspace reading on the field form or in the field book.

Note:	*Perform all headspace readings in an area that is not subject to wind. Also, in the winter, it is necessary to allow the samples to equilibrate in a warm area (e.g., site trailer, van, etc.). This requirement is dictated by the Work Plan.*

All head space measurements must be completed under similar conditions to allow comparability of results.

NAPL Detection

During soil examination and logging, the sampler shall carefully check for the presence of light or dense non-aqueous phase liquid (NAPL). NAPL may be present in gross amounts or present in small/minute quantities. The adjectives and corresponding quantities used when describing NAPL within a soil matrix are as follows:

Visual Description	***Fraction of Soil Pore Volume Containing NAPL***
Saturated	>0.5
Some	0.5 to 0.25
Trace	<0.25

A complete description of NAPL, must describe the following:

- Color.
- Quantity.
- Density (compared to water i.e., light/floats or heavy/sinks).
- Odor (if observed).
- Viscosity (i.e., mobile/flowable, non-mobile/highly viscous-tar like).

The presence of an "iridescent sheen" by itself does not constitute "NAPL presence", but may be an indicator that NAPL is close to the area.

NAPL presence within a soil matrix may be confirmed by placing a small soil sample within water, shaking, and observing for NAPL separation (i.e., light or dense), from the soil matrix.

Trace amounts of NAPL are identified/confirmed by a close visual examination of the soil matrix, [i.e., separate soil by hand (wearing disposable gloves)] and perform a careful inspection of the soil separation planes/soil grains for NAPL presence.

Often during the sample examination with a knife, an iridescent sheen will be noted on the soil surface (i.e., clay/silts) if the knife has passed through an area of NAPL.

There are a number of more sophisticated tests available to confirm/identify NAPL presence, these are:

- UV fluorescent analysis.
- Hydrophobic dyes.
- Centrifugation.
- Chemical analysis.

Typically consultants will utilize organic vapor detection results, visual examination, soil/water shake testing, and chemical analysis, to confirm NAPL presence. The more complex techniques described may be incorporated on sites where clear colorless NAPL is present and its field identification is critical to the program.

Note: When describing the presence of vegetative matter in the soil sample, do not use the term "organic" as this often leads to confusion with regards to the presence of organic chemicals (i.e., NAPL).

EQUIPMENT/MATERIALS

- Pocket knife or small spatula.
- Small handheld lense.
- Form FMG 2.6-01 - Stratigraphic Log - Overburden (Page 1/Page 2).
- Tape measure.

REFERENCES

American Society for Testing and Materials (1991), Standard D1452-80, "Practice for Soil Investigation and Sampling by Auger Borings", "Annual Book of ASTM Standard", Section 4, Volume 04.08.

ASTM Standards on Environmental Sampling (1995), Standard D2488-93, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"

ASTM Standards on Environmental Sampling (1995), Standard D4700-91, "Guide for Soil Sampling from the Vadose Zone".

ASTM Standards on Environmental Sampling (1995), Standard D1586-92, "Test Method for Penetration Test and Split-Barrel Sampling of Soils".

ASTM Standard D2487, "Classification of Soils for Engineering Purposes (Unified Soil Classification System)".

Geotechnical Gauge, Manufactured by W.F. McCollough, Beltsville, MD.

Sand Grading Chart, by Geological Specialty Company, Northport, Alabama.

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BEDROCK CORING

INTRODUCTION

The following procedures describes the methodology for bedrock coring.

PROCEDURES REFERENCED

- FMG 2.7 - Rock Classification.

PROCEDURAL GUIDELINES

- Prior to initiating coring activities, ensure that the overburden portion of the hole is isolated from the bedrock portion of the hole using an overburden casing routed in place.
- Coring must be performed utilizing an approved coring method and size, and performed with wire line coring techniques.
- Potable water or air can be utilized as circulating medium.
- If required, all rock cuttings produced will be properly contained and disposed of in accordance with the Work Plan requirements.
- All coring activities shall be performed following procedures outlined in ASTM D2113.
- Upon completion of the coring activities the core hole shall be flushed to remove all residual rock cuttings from the bottom of the corehole.
- All bedrock core runs should be completed without interruption so penetration rates can be determined.
- Upon completion of bedrock coring activities, the corehole shall be flushed to remove all residual bedrock cuttings and measured to confirm final depth.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Appropriate coring equipment.

- Form FMG 2.7-01 - Bedrock Stratigraphic Log.
- Tape measure.
- Hand lense.
- Camera.
- Work Plan.
- Health and Safety Plan.

REFERENCES

American Society for Testing and Materials (1991) Standard D2113-8307 "Standard Practice for Diamond Core Drilling for Site Investigations" Annual Book of ASTM Standards, Section 4, Volume 04.08.

American Society for Testing and Material (1991) Standard D5434-93 "Standard Guide for Field Logging of Subsurface Exploration of Soil and Rock" Annual Book of ASTM Standards, Section 4, Volume 04.09.

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ROCK CLASSIFICATION

INTRODUCTION

This procedure is for the logging and classification of bedrock cores.

PROCEDURES REFERENCED

- FMG 2.4 - Bedrock Coring.

PROCEDURAL GUIDELINES

- All bedrock logging activities will be conducted according to procedures outlined in ASTM D5434-93.
- All retrieved bedrock core shall be handled in a manner as to cause the least amount of mechanical fractures as possible.
- All retrieved bedrock cores will be placed in an appropriate sized core box with increasing depths aligned left to right.
- All bedrock core runs shall be separated and core depths marked utilizing wooden blocks.
- Upon the completion of each core run, the depth of corehole will be measured to properly document the termination depth of each core run.
- Each stratigraphic bedrock core run will be logged for all structural and lithographic features.
- All natural occurring fractures, structural and lithographic features will be logged for depth and documented on standard Form FMG 2.7-01 - Bedrock Stratigraphic Log.
- Rock Quality Designation (RQD) values and documentation on the bedrock log form will be calculated for each bedrock core run.
- RQD values will be calculated to indicate rock-mass properties according to Deere (1986) by summarizing all the bedrock core portions greater than 4 inches in length and dividing the sum of these pieces by the length of the bedrock core run. RQD is expressed as a percentage.
- The percentage of bedrock core recovery for each core run will be calculated and recorded on Form FMG 2.7-01 - Bedrock Stratigraphic Log.

- If potable water is utilized as a circulating medium, the volume of water lost during each bedrock core run will be recorded on Form FMG 2.7-01 - Bedrock Stratigraphic Log.
- Special attention will be paid to fracture surfaces to indicate if any fracture infilling or groundwater movement is indicated. All fractures will be measured for depth and recorded on Form FMG 2.7-01 - Bedrock Stratigraphic Log.
- A picture of each run of bedrock core will be taken to document each retrieved bedrock core run.
- Each completed core box fill be properly sealed to keep the bedrock core intact.
- Each core box will be labeled on the outside to include site name, job number, boring number, date, bedrock core depth, interval, bedrock core run number, RQD and bedrock core recovery for each core run, fluid loss (if applicable), and bedrock core loggers name.
- Upon completion of bedrock coring activities the corehole should be flushed to remove all residual rock cuttings from the corehole and measured to ensure that the documented termination depth of the corehole is correct.
- Ensure that all bedrock coring equipment is properly decontaminated according to site protocols prior to construction of the next well.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Appropriate coring equipment.
- Form FMG 2.7-01 - Bedrock Stratigraphic Log.
- Tape measure.
- Hand lense.
- Camera.
- Work Plan.
- Health and Safety Plan.

REFERENCES

American Society for Testing and Materials (1991) Standard D2113-8307 "Standard Practice for Diamond Core Drilling for Site Investigations" Annual Book of ASTM Standards, Section 4, Volume 04.08.

American Society for Testing and Material (1991) Standard D5434-93 "Standard Guide for Field Logging of Subsurface Exploration of Soil and Rock" Annual Book of ASTM Standards, Section 4, Volume 04.09.

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WELL CONSTRUCTION MATERIALS

INTRODUCTION

In environmental subsurface investigations, the information used to evaluate subsurface conditions often relies heavily on the installation of quality groundwater monitoring wells. The application and use of the proper well construction materials to the specific well installation is crucial to obtaining representative and reliable groundwater samples.

The two general types of wells are groundwater monitoring wells and pumping (also referred to as recovery, extraction, or withdrawal) wells. The specific use of a groundwater well dictates the types of materials used to construct it.

This FMG outlines the general types and use of well construction materials and considerations involved in selecting appropriate materials for specific well installation applications. Installation of these materials are described in detail in the specific well installation FMGs listed below.

PROCEDURES REFERENCED

- FMG 3.2 - Overburden Wells.
- FMG 3.3 - Top of Bedrock Wells.
- FMG 3.4 - Deep Bedrock Wells.
- FMG 3.5 - Pump Wells.
- FMG 3.6 - Piezometers.

EQUIPMENT DESCRIPTIONS

Well Screen

Well screen is the portion of the well pipe that contains appropriately sized openings and allows groundwater to enter the well. The screen materials used in groundwater monitoring wells are crucial to ensuring the installation of an efficient, productive, and durable groundwater well.

The diameter of the well screen is generally dependent upon the application of the well. For monitoring wells used in groundwater level measurements and groundwater sampling, screen diameter will generally be 2.0-inch inner diameter (ID) flush-threaded screen segments (piezometers are typically 1.0-inch inner diameter but may be 2-inch also). These screen segments are typically available in 10-foot lengths. Four-inch diameter or larger well screens are usually reserved for recovery or production well applications where larger diameters permit greater groundwater withdrawal rates. Larger diameter wells also allow a well to serve additional functions such as housing oil recovery systems.

Screen material will be either thermoplastic Schedule 40 Poly Vinyl Chloride (PVC) (ASTM D1785, ASTM D2665, ASTM F480) or Schedule 5 Type 316 stainless steel, depending primarily on the depth of the well and the groundwater quality (degree and nature of contamination). Shallower depths and generally low levels of contaminants in groundwater allow for PVC applications, whereas greater depths and severely degraded groundwater quality, or the presence of free-phase oils or solvents, may necessitate stainless steel due to its greater strength and resistance to chemical degradation. It should be noted that PVC and stainless steel are appropriate for the vast majority of environmental applications, and are generally accepted by regulatory agencies. Well materials other than PVC or stainless steel should be used only in certain instances, to be determined and approved by the Project Manager on a case-by-case basis.

Certain applications such as investigation of inorganic (metals) concentrations in groundwater, or the presence of low pH (acidic) conditions, may preclude the use of stainless steel wells. Stainless steel, which contains molybdenum in addition to its iron content, may leach out metal compounds which could lead to misleading groundwater analysis results.

PVC may likewise leach out or degrade specific thermoplastic elements of its composition which may compromise the well integrity or groundwater analyses. PVC generally performs well in acidic groundwater conditions; however, it may degrade in the presence of certain organic compounds such as ketones, aldehydes, or chlorinated compounds in high concentrations. Certain additives to the PVC may also affect groundwater quality.

Well screen slot sizes and well screen type will also be consistent for groundwater monitoring wells. Screen slot size is typically 0.010 inches; 0.020-inch slot size may be more appropriate for coarser formation materials or where the well may serve as a recovery well for free-phase oils. For monitoring applications, slot type should be either factory machine-slotted or continuous-wrap slotted. Perforated, bridge-slotted or louver-slotted well screens are generally not acceptable for most environmental applications and should be avoided.

Screen slot sizes may vary from these two sizes when used in production or recovery (pumping) well applications where the need to maximize groundwater withdrawal is essential. In such cases, screen slot sizes can be manufactured to exact specifications for a particular well based on particle size analysis results and formation transmissivity or permeability.

Well Riser Pipes and Casings

Well riser pipe is a solid extension of the well screen that extends from the screen up to the surface. The riser pipe protects the well screen, prevents outside groundwater from entering the well, and allows groundwater pumped from down in the open interval to be routed up through the well to the surface.

Well riser pipe should be of the same material and size as the well screen described above. In instances to be determined and approved by the Project Manager on a case-by-case basis only, differing materials may be approved for use in the same well (e.g., stainless steel well screen connected to PVC riser). Well risers should extend to the surface and should either be cut at grade in flush-mount completions or as an approximately 3-foot stickup to be covered with a steel protective casing.

Well riser pipe sections shall be flush-threaded and fitted with neoprene, rubber, or other appropriately constructed, durable o-rings to properly seal the threaded pipe joints. Glues or cements are not to be used in well construction.

In installations of bedrock monitoring wells, which have an open rock monitoring interval and a permanent well casing that extends from bedrock to the surface, the permanent casing (or casings in telescoping wells) shall be made of carbon steel or low-carbon steel (greater than 0.8 percent carbon and less than 0.8 percent carbon, respectively). The well casing should be a minimum of 4 inches in diameter (at least 4 inches diameter for the innermost casing).

On sites wells where dense, non-aqueous phase liquid (DNAPL) is present or may be a concern, in screened wells it is advisable to install a collection sump on the base of the well below the well screen to collect infiltrated DNAPL for possible measurement and/or sampling. Sumps should be installed as a 1- to 5-foot section of solid riser material with a sealed bottom placed below the well screen.

Sand Packs

The filter pack, or sand pack, installed in a well replaces formation material immediately around a well with a more permeable material (sand). The sand pack separates the well screen from the formation, increases the hydraulic diameter of the well, and prevents fines (silt or clay) from entering or clogging the well screen.

Sand pack of an appropriate size shall be utilized based on the well screen slot size being used. Sand pack size should be chosen so that the majority of the sand (sand pack has inherent variation in its particle grain size distribution) is larger than the screen slot size while sized small enough to prevent deleterious amounts of formation fines from entering the well through the sand pack. Screen slot sizes of 0.010-inch and 0.020-inch typically use a sand pack such as Morie or U.S. Silica No. 1, No. 0, No. 00N, or equivalent.

Sand pack shall be washed silica sand with a silica content of at least 95 percent. Sands should meet one or more of the following requirements: NSF 61, AWWA B-100, ANSI, or equivalent standards for uniformity and chemical inertness. In cases to be determined and approved by the Project Manager on a case-by-case basis only, differing sand pack materials may be approved for use in a well. Sand packs used for production and recovery wells with larger screen slot sizes will use larger particle sized sand packs of the same type and quality. The slot size and sand pack size for recovery wells should be chosen based on results of formation grain size distribution analysis.

Seals

Bentonite and grout seals are installed above the sand pack to isolate the monitoring interval and prevent groundwater from infiltrating into the well screen from other water-bearing zones. Seals also prevent migration of backfill or formation materials downward into the sand pack.

Bentonite is the generic name for a group of a naturally occurring clay minerals (montmorillonites) that come in a variety of forms: pellets, chips, granulated, or powdered. This material is commercially available as "Wyoming Bentonite". When hydrated it swells to many times its original volume and forms an ultra-low permeability clay seal.

Bentonite chips or pellets are generally used to create a seal immediately above the sand pack. The chips/pellets are dropped inside the augers or well casing by hand down through the water column onto the top of the sand pack. Care must be taken to prevent "bridging" of the bentonite particles in the casing above the target zone. Measurements of the depth to the top of the seal must be obtained during installation of the seal to ensure its proper position and thickness. In the absence of significant water in a casing or borehole, potable water must be added to hydrate the bentonite. The bentonite seal will be allowed to set for a minimum of one-half hour, in order to hydrate properly, before additional seals (grout) are applied. Once the bentonite has set for one-half hour the grout seal may be placed, as described below.

In saline groundwater environments, such as where ocean water may infiltrate the monitoring interval, a zeolite-based seal material may be used, as saline conditions may hamper the performance of bentonite pellets.

Portland cement grout (grout) forms a concrete-like seal that can be more manageable than bentonite (e.g., able to be pumped through a water pump). Grout is generally placed on top of the hydrated bentonite seal to form a solid cement seal around the well riser up to the surface. In certain circumstances, only under approval of the GM Project Manager, soil cuttings may be used to backfill the borehole in lieu of grout.

The grout mixture will consist of one 94-pound bag of Portland cement and 3 to 5 pounds of powdered bentonite added per sack of cement. Two pounds of calcium chloride may also be added (under certain conditions, e.g., very cold days) to accelerate the setting time of the grout, as well as to increase the dry strength of the grout. The grout will be thoroughly mixed with 6.5 gallons of potable water per sack of cement. Grout is generally placed using either the tremie or Halliburton grouting methods. These are described in the specific well installation FMGs.

Protective Casings and Surface Seals

Once the well screen, riser, and all seals have been placed to ground surface, the well riser must be protected. This includes protection from vehicles, damage, surface water infiltration, and weather. This is typically accomplished using either a flush-mount roadbox or a stickup casing.

Flush-mount roadboxes are circular steel casing segments with a heavy-duty steel lid with locking bolts. These units are widely available and come in a number of diameters and lengths, depending on the well diameter. A stickup protective casing is generally a length of carbon or stainless steel pipe with a locking top.

For a typical 2-inch monitoring well, the roadbox should be at least 6 inches in diameter; a stickup casing should be at least 4 inches in diameter. A roadbox should be at least 12 inches in length (they are typically 16 to 18 inches long) and is installed flush with the ground surface. A stickup casing should be at least 5 to 6 feet long such that approximately 2.5 to 3 feet is below ground surface and 2.5 to 3 feet is protruding above grade. In wells where a permanent steel casing is installed (serves as the well riser pipe) and brought to the ground surface, it may be used as the protective casing provided it is equipped with a semi-permanent, metal, locking cap or cover that can be affixed to the steel casing.

Flush-mount installations should have at least the last 18 inches of the open borehole filled with coarse sand, placed up to ground surface to allow drainage of surface water infiltration down through and out of the roadbox. This also prevents infiltrating surface water from accumulating up over the top of the well riser and draining down into the well. This sand drain is not necessary in the locking cap stickup casings.

Both roadbox and stickup casings must be secured in the ground with concrete, which also serves as a surface seal.

In areas of high vehicle traffic activity, protective steel bollards should be installed. This is typically a vertically oriented, concrete-filled, steel pipe (minimum 4 inches diameter) cemented at least 3 feet into the ground, acting as a "guard rail" for the well casing and preventing it from being damaged by vehicles. Three bollards should be placed around a well to provide adequate protection.

EQUIPMENT/MATERIALS

- Drilling equipment.
- Well screen and riser materials.
- Sand pack.
- Bentonite pellets/chips.
- Powdered bentonite.
- Portland cement.

REFERENCES

ASTM D1785-99, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

ASTM D2665-00, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

ASTM F480-00, Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and Schedule 80.

ASTM A53/A53M-01, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless for Ordinary Uses.

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FMG 3.4-01 BEDROCK WELL INSTALLATION

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 3.4
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS LLC	
REVISION NO.: 1	REVISION DATE: SEPTEMBER 22, 2002

DEEP BEDROCK WELLS

INTRODUCTION

This procedure is for the installation of deep groundwater monitoring wells in bedrock zones which lie below the top of bedrock groundwater flow zone.

PROCEDURES REFERENCED

- FMG 2.0 - Subsurface Investigations.
- FMG 3.0 - Monitoring Wells, Pump Wells, and Piezometers.
- FMG 5.0 - Aquifer Characterization.
- FMG 9.0 - Equipment Decontamination.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

- Overburden drilling will be performed down to the top of bedrock surface in accordance with the procedures outlined in FMG 3.3 - Top of Bedrock Wells. Once at the top of bedrock surface, the augers will be advanced a minimum of 1 foot into bedrock, if possible.
- If the augers cannot be advanced the minimum 1 foot into bedrock, the augers will be removed and a temporary 8-inch steel casing will be placed to the bottom of the borehole to seal off the overburden. The seal shall be augmented by either pounding or spinning the casing just into the top of bedrock.
- Once the augers or casing are in place, either bedrock coring or 7 7/8-inch rotary drilling using standard techniques will be performed to advance the corehole to the depth of the top of the desired open monitoring interval. If cored, the core boring will be reamed to a nominal 8-inch diameter with a rotary bit. Bedrock coring will be performed in accordance with procedures outlined in ASTM D2113 and FMG 2.4 - Bedrock Coring.
- Bedrock logging and classification will be performed in accordance with FMG 2.7 - Rock Classification.

- Once at the top of the desired monitoring interval a 4-inch diameter permanent black-iron or steel casing equipped with centralizers will be installed. The casing will be grouted in place to within 6 inches of the base of the borehole using either the Halliburton single-plug grouting method or by tremie grouting, as described below. Grout will be mixed according to the specifications presented in FMG 3.1 - Well Construction Materials.

<u>Halliburton Method</u>

- Approximately 1.5 times the total calculated annular space volume of grout will be mixed. The grout will be placed inside the casing and a drillable plug (made of inert material which shall not result in the introduction of contaminants to the well) will be placed on top of the grout. The plug must fit tight enough to prevent the mixing of the grout with the water above the plug. Potable water will be injected under pressure into the casing, forcing the plug to the bottom of the casing and grout into the annular space. A valve on the freshwater line will be closed to maintain pressure on the plug and the grout will be allowed to set for at least 12 hours. The temporary casing or auger assembly will be gradually withdrawn during the grouting process. The Halliburton method may also employ the use of drilling rods, in lieu of pressurized water, to force the plug down through the casing and maintain pressure on the plug.

<u>Tremie Grouting Method</u>

- A temporary tremie pipe will be installed to the depth of the bottom of the 4-inch casing in the annular space between the 4-inch casing and the 8-inch borehole wall. Grout will be pumped through the pipe until undiluted grout return is noted at the ground surface in the annular space between the 4-inch casing and the temporary casing or augers. The temporary casing or auger assembly will then be gradually withdrawn: the tremie pipe will be disconnected from the grout pump without removing it from the bottom of the borehole, temporary casing sections or auger flights will be withdrawn one at a time, the tremie pipe will be reconnected, and additional grout will be pumped until grout return is again observed at the ground surface inside and outside the temporary casing or augers. This procedure will be repeated, thereby maintaining a full head of grout in the casing, until the temporary casing or auger string has been completely withdrawn. Additional grout will then be pumped through the tremie pipe if necessary to achieve and maintain undiluted grout at ground surface outside the 4-inch casing. The tremie pipe will then be withdrawn from the borehole.
- The grout will be allowed to set for a minimum of 12 hours prior to resuming drilling operations.
- Drill excess grout out of the casing first with a tri-cone roller-bit of a diameter just slightly less than the inner diameter of the casing.
- At most locations, after the casing grout has set, an NQ or NX-core boring will be advanced approximately 10 feet (or alternate length to serve as the desired monitoring interval) below

the 4-inch casing seat. The cored interval will serve as the monitoring interval for most locations, or the corehole may be reamed to a nominal 4-inch diameter.

- In some instances, depending on factors such as degree of rock competency (i.e., low-competency rock), groundwater quality, etc., a well screen may be appropriate for the monitoring interval. In such cases, a 2-inch-diameter stainless-steel or PVC well screen, machine-slotted or continuous wrapped, with 0.020-inch slot screen size, and equal in length to the cored interval may be installed within the open bedrock interval. A riser pipe of similar material will be attached to complete the well screen to the surface. In such cases the annular space between the well screen and corehole will be filled with a sandpack of appropriate grain size distribution to match the screen slot size. Seals of bentonite (minimum 2 feet thick) and grout may be installed above the sandpack to fill the annular space between the 2-inch riser and 4-inch casing, although these are not required since the screen is for stability purposes only and the monitoring interval has already been isolated.
- On sites wells where dense, non-aqueous phase liquid (DNAPL) is present or may be a concern, in screened wells it is advisable to install a collection sump on the base of the well below the well screen to collect infiltrated DNAPL for possible measurement and/or sampling. Sumps should be installed as a 1- to 5-foot section of solid riser material with a sealed bottom placed below the well screen.
- Well screen "centralizers" may also be used in deeper wells to ensure that the well screen remains centered in the borehole at depth and facilitating an even distribution of the sand pack around the screen. These are generally a steel bracket or clamping device affixed (prior to installation) at one or more locations along the lower portion of the well screen and riser pipe. Centralizers are recommended but may be omitted if approved by the GM Project Manager. Care must be taken to insure that bridging of sand or bentonite does not occur at the centralizer locations.
- The well casing will be secured with a vented lockable cap. If the well is located in a high traffic area, the casing will be cut below grade and packed in coarse sand for drainage. The casing will be protected by a 9-inch flush-mounted roadway box set in a concrete seal. Alternatively, in low traffic areas, the well casing may be cut above grade and completed with a locking steel protective casing with approximately 3 feet of stickup, set in a concrete surface seal. Protective steel bollards will be installed, where necessary, to protect the well casing. Refer to FMG 3.1 - Well Construction Materials for additional information regarding protective casings.
- For deep bedrock monitoring well installation, where multiple zones of permeable rock may exist, steel casings and rotary drilling bits of larger size than indicated in this FMG may be used to create "telescoping" wells in which the sizes of the casings and boreholes become progressively smaller with increased depth. The deeper the well installation, the larger the diameter required for the near-surface (initial) drilling. Each permanent steel casing shall be grouted in place, using the methods described herein.

- Bedrock coring and deep bedrock well installations may also be performed in conjunction with packer pressure testing (FMG 5.4 - Packer Pressure Testing) in order to define more permeable bedrock zones or to target specific hydrogeologic zones.
- All equipment will be decontaminated in accordance with FMG 9.0 - Equipment Decontamination, and all drilling-related wastes shall be handled and disposed in accordance with FMG 10.0 - Waste Characterization.
- Well installation will be followed by development. The procedure for well development is described in FMG 3.7 - Well Development. Water level monitoring will be performed in accordance with FMG 5.1 - Water Level Measurements.
- If required, in situ hydraulic conductivity testing shall be done in accordance with FMG 5.2 - In Situ Hydraulic Conductivity (Slug Test) Procedure.

EQUIPMENT/MATERIALS

- Well construction materials.
- Water level probe.
- Form FMG 3.4-01 - Bedrock Well Installation.
- Weighted tape measure.

REFERENCES

ASTM D1452-80, "Practice for Soil Investigation and Sampling by Auger Borings", Annual Book of ASTM Standard, Section 4, Volume 04.08.

ASTM D2113-83 (87), "Diamond Core Drilling for Site Investigations", Annual Book of ASTM Standards, Section 4, Volume 04.08.

American Society for Testing and Materials (1991), Standard D5092, "Practices for Design and Installation of Ground Water Monitoring Wells in Aquifers", Annual Book of ASTM Standard, Section 4, Volume 04.08.

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FMG 6.1-01 SOIL SAMPLE SELECTION DETAILS

SOIL

INTRODUCTION

The following procedure describes typical soil sample collection methods for submission of samples to a laboratory for chemical analysis. Three sample situations are presented: soil sampling from surficial soils, soil sampling from subsurface samplers such as a split-spoon sampler or a direct push sampler, and lastly soil sampling from a test pit.

Soil sampling procedures may vary from project to project due to different parameters of concern, different guidance provided by the state/province where the site is located, or the specific objectives for the project. Therefore, it is essential that the sampling team members carefully review the Work Plan requirements and the rationale behind the program. The primary goal of soil sampling is to collect representative samples for examination and chemical analysis (if required).

Grab Versus Composite Samples

A grab sample is collected to identify and quantify compounds at a specific location or interval. The sample shall be comprised of no more than the minimum amount of soil necessary to make up the volume of sample dictated by the required sample analyses. Composite samples are a mixture of a given number of sub-samples and are collected to characterize the average chemical composition in a given surface area or vertical horizon.

PROCEDURES REFERENCED

- FMG 2.1 - Test Pits.
- FMG 2.2 - Drilling Techniques.
- FMG 2.3 - Soil Borings.
- FMG 2.6 - Soil Classification.
- FMG 6.10 - Sample Handling and Shipping.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

1. SURFICIAL SOIL SAMPLE COLLECTION

1.1 Sample Strategy -Random, Biased, and Grid-Based Sampling

Unless there is a strong indication of contaminant presence, such as staining, then soil sample locations may be randomly selected from several areas within the site.

If any areas show evidence of contamination, such as staining or vegetative stress, biased samples shall be collected from each area to characterize the contamination present in each area. Background and control samples are also biased, since they are collected in locations typical of non-site-impacted conditions.

When soil sampling investigations involve large areas, a grid-based soil sampling program is used. There is no single grid size that is appropriate for all sites. Common grid sizes are developed on 50-foot and 100-foot centers. It is acceptable to integrate several different grid sizes in a single investigation.

For surficial soil sampling programs, it is also important to consider the presence of structures and drainage pathways that might affect contaminant migration. It is sometimes desirable to select sampling locations in low lying areas which are capable of retaining some surface water flow since these areas could provide samples which are representative of historic site conditions (worst-case scenario if surface water flow was a concern).

1.2 Sample Interval

Surficial soils are generally considered to be soil between ground surface and 6 to 12 inches below ground surface. However, for risk assessment purposes, regulatory authorities often consider soil from ground surface to 2 feet below ground surface to be surficial soil. The exact interval to be considered as surficial soil is often a matter of discussion with the regulatory authorities that review the Work Plan. The sample interval is important to the manner in which the data are ultimately interpreted. Another important factor is the type of soil. If there are different types of soil present at the site, this may have a bearing on the sample interval. For example, it may be important to separately sample a layer of material with high organic carbon content which overlies a layer of fine grained soil.

1.3 Surface Sampling Procedure

Soil sampling techniques are dependent upon the sample interval of interest, the type of soil material to be sampled, and the requirements for handling the sample after retrieval. The most common method for collection of surficial soil samples involves the use of a stainless steel trowel. Soil samples may also be collected with spoons and push tubes. The sampling equipment is cleaned between sample locations. A typical surficial soil sampling protocol is outlined below:

- Surficial soil samples will be collected using a precleaned stainless steel trowel or other appropriate tool. Each sample will consist of soil from the surface to the depth specified within the Work Plan.
- A new pair of disposable gloves will be used at each sample location.
- Any surficial debris (i.e., grass cover, gravel) should be removed from the area where the sample is to be collected using a separate precleaned device. Gravel presents difficulties for the laboratory in terms of sample preparation and is typically not representative of contaminant concentrations in nearby soil.
- A precleaned sampling tool will be used to remove the sample from the layer of exposed soil.
- When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for volatile organic compounds analyses shall <u>not</u> be mixed.
- Samples will be placed on ice or cooler packs in laboratory supplied shipping coolers after collection.

Exception is noted for the collection of volatile organic compounds (VOCs) which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected using an EnCore Sampler™ (triplicate samples collected in accordance with manufacturer's instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

2. SUBSURFACE SAMPLE COLLECTION

Subsurface soil sample collection is typically performed with the help of a drill unit, direct-push probing unit, or hand-driven/held samplers. Typically a boring is advanced incrementally to permit intermittent or continuous sampling to the required depth of chemical sample collection;

or alternatively sampling may be initiated if certain conditions are observed (i.e., chemical presence or volatile presence identified from monitoring). Sample collection criteria and locations, are normally stipulated by the Work Plan.

Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test or other sampling technique is performed on essentially undisturbed soil is acceptable. The drilling method is to be selected based on the subsurface conditions. Each of the following procedures have proven to be acceptable for specific subsurface conditions:

- Conventional drilling with continuous flight hollow-stem auger (HSA) method (with inside diameter between 2.2 and 6.5 inches) using split-spoon samplers (Standard Penetration Test – STP) or Shelby tube samplers; or
- Direct-push samplers, advanced using a percussion/vibratory hammer (Geoprobe™ or equivalent); or
- Hand–held/driven split-spoon sampling equipment or portable hammer and split-spoon sampling equipment (final depth will be limited).

Several drilling methods are not acceptable. These include: jetting through an open tube sampler and then sampling when the desired depth is reached; use of continuous flight solid auger equipment below the groundwater table in non-cohesive soils; casing driven below the sampling depth prior to sampling; and advancing a borehole with bottom discharge bits.

The following subsections describe the specific methods for completing split-spoon sampling, Shelby tube sampling, and direct-push sampling. Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from any of the above sample collection devices.

2.1 Split–Spoon Sampling Method

This method is used to obtain representative samples of subsurface soil materials for sample collection. The test methods described below must be followed to ensure that the soils captured in the split-spoon or Shelby tube are relatively undisturbed/representative of the desired soil interval and obtain accurate SPT values. The SPT values reflect the subsurface soils density and is typically measured when performing geotechnical work or environmental borings. This information although not directly relevant to the collection of chemical samples, is collected because it is beneficail in terms of stratigraphy interpretation and understanding the conditions below grade.

The split barrel sampler, or split spoon, consists of an 18- or 24-inch long, 2-inch outside diameter tube, which comes apart length wise into two halves. Larger spoons are available for use when a larger sample volume is required (4-inch diameter spoons).

Once the borehole (i.e., HSA) is advanced to the target depth and the borehole cleaned of cuttings, representative soil samples are collected in the following manner:

- The split-spoon sampler should be inspected to ensure it is properly cleaned and decontaminated. The driving shoe (tip) should be relatively sharp and free of severe dents and distortions.
- The cleaned split-spoon sampler is attached to the drill rods and lowered into the borehole. Do not allow the sampler to drop onto the soil.
- After the sampler has been lowered to the bottom of the hole, it is given a single blow to seat it and make sure that it is in undisturbed soil. If there still appear to be excessive cuttings in the bottom of the borehole, remove the sampler from the borehole and remove the cuttings.
- Mark the drill rods in three or four successive 6-inch (0.15 m) increments, depending on sampler length, so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-inch (0.15 m) increment.

The sampler is then driven continuously for either 18 or 24 inches (0.45 or 0.60 m) by use of a 140-pound (63.5 kg) hammer. The hammer may be lifted and dropped by either the cathead and rope method, or by using a trip, automatic, or semi-automatic drop system. The hammer should free-fall a distance of 30 inches (±1 inches) (760 mm, ±25 mm) per blow. Measure the drop at least daily to ensure that the drop is correct. To ensure a free-falling hammer, no more than 2 1/4 turns of the rope may be wound around the cathead (see ASTM D1586-84). The number of blows applied in each 6-inch (0.15 m) increment is counted until one of the following occurs:

- A total of 50 blows have been applied during any one of the 6-inch (0.15 m) increments described above;
- A total of 100 blows have been applied;
- There is no advancement of the sampler during the application of ten successive blows of the hammer (i.e., the spoon is "bouncing" on a stone or bedrock); or
- The sampler has advanced the complete 18 or 24 inches (0.45 or 0.60 m) without the limiting blow counts occurring as described above.

In some cases where the limiting number of blow counts has been exceeded, the field supervisor may direct the driller to attempt to drive the sampler more if collection of a greater sample length is essential.

On the field form, record the number of blows required to drive each 6-inch (0.15 m) increment of penetration. The first 6 inches is considered to be a seating drive. The sum of the number of blows required for the second and third 6 inches (0.15 m) of penetration is termed the "standard penetration resistance" or the "N-value".

Note: If the borehole has sloughed and there is caved material in the bottom, the split spoon may push through this under its own weight, but now the spoon is partially "pre-filled". When the spoon is driven the 18 or 24 inches representing its supposedly empty length, the spoon fills completely before the end of the drive interval. Two problems arise:

1. *the top part of the sample is not representative of the in-place soil at that depth; and*
2. *the SPT value will be artificially higher toward the bottom of the drive interval since the spoon was packed full. These conditions should be noted on the field log.*

The sampler is then removed from the borehole and unthreaded from the drill rods. The open shoe (cutting end) and head of the sampler are partially unthreaded by the drill crew and the sampler is transferred to the field supervisors work surface.

The open shoe and head are removed by hand, and the sampler is tapped so that the spoon separates.

Measure and record the length of sample recovered making sure to discount any sloughed material that is present on top of the sample core.

Caution must be used when conducting SPT sampling below the groundwater table, particularly in sand or silt soils. These soils tend to heave or "blow back" up the borehole due to the difference in hydraulic pressures between the inside of the HSA and the undisturbed soil. To equalize the hydraulic pressure, the inside of the HSA must be filled with water. The drilling fluid level within the boring or HSA needs to be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling. Since heave or blow back is not always obvious to the driller, it is essential that the water level in the borehole always be maintained at or above the groundwater level.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a split-spoon sampler.

2.2 Thin-Walled (Shelby Tubes) Sample Method

Thin-walled samplers are used to collect relatively undisturbed samples (as compared to split-spoon samples) of soft to stiff clayey soils. Shelby tubes are commonly used. The Shelby tube has an outside diameter of 2 or 3 inches and is 3 feet long. These undisturbed samples are used for certain laboratory tests of structural properties (consolidation, hydraulic conductivity, shear strength) or other tests (such as collection of soils for chemical analysis) that might be influenced by sample disturbance. Procedures for conducting thin-walled tube sampling are provided in ASTM D1587-94, and are briefly described below.

- The soil deposit being sampled must be cohesive in nature, and relatively free of sand, gravel, and cobble materials, as contact with these materials will damage the sampler.

- Clean out the borehole to the sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above groundwater level during the sampling operation.
- Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or HSA as carefully as possible to avoid disturbance of the material to be sampled.
- Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler into the formation without rotation by a continuous and relatively rapid motion; usually hydraulic pressure is applied to the top of the drill rods.
- Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.
- In no case should the length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 inches for cuttings.
- The tube may be rotated to shear the bottom of the sample 2 to 3 minutes after pressing in, and prior to retrieval to ensure the sample does not slide out of the tube. Lift the weight of the rods off of the tube prior to rotating.
- Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

On occasion it maybe required that extraction of the sample from the tube be conducted in the field for chemical sample collection. The following procedure should be followed.

- A sample extruder, which consists of a clamp arrangement to hold the tube and a hydraulic ram to push the sample through the tube, is usually mounted on the side of the rig. To prevent cross-contamination, be certain that the extruder is field cleaned between each sample.
- The sample is then extruded into a carrying tray; these are often made from a piece of 4-inch or 6-inch diameter PVC pipe cut lengthwise. Be certain that the carrying tray is field cleaned between each sample. The sample is carried to the work station to describe the sample, trim the potentially cross-contaminated exterior, and select the area for sample collection (see Section 2.4 - Soil Core Chemical Sample Collection Procedure). Form FMG 6.1-01 - Soil Sample Selection Details shows the method for obtaining a soil sample from a Shelby tube soil core.
- The Shelby tube may then be thoroughly field cleaned and decontaminated for reuse. Since they are thin-walled, the tubes are easily damaged, crimped, or otherwise distorted during handling or pushing. The Shelby tube should be inspected before use and any which are significantly damaged should be rejected.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a Shelby tube sampler.

2.3 Direct-Push Sample Method

The operation of the direct-push samplers (i.e., Macro-Core™ Soil Sampler or equivalent) consists of "pushing and/or vibrating" the sampler into the subsurface using a direct-push unit (i.e., Geoprobe™ soil probing machine or equivalent). The sampler is typically a hollow tube with a threaded drive head, and threaded cutting shoe; provided with an internal sleeve (i.e., liner) that the soil sample is captured in.

Once driven to the required depth, the sampler body/soil liner and soil core is removed from the borehole for inspection and sample collection. Once above grade the sampler is opened by the probe operator and the liner removed and cut open (opened with a dual blade cutting tool), to expose the soil for inspection and sampling.

The sampler body and ends are decontaminated, and a new liner is inserted and the sampler reassembled for collection of the next interval. The clean sampler is then advanced back down the same hole to collect the next soil sample. The Macro-Core™ sampler can be used in either the open-tube or closed-point sampling mode. The open-tube is most commonly used method, typically employed in stable soil conditions when the borehole does not collapse. The closed-point system seals the cutting shoe opening until the sampler is at the next sample interval, this prevents collapsed soil from entering the sampler as it is advanced back down the hole. Once at the sample depth, the closed-point is unthreaded and released from the cutting shoe area, such that it rides on top of the soil core as it is being driven into the next interval.

Section 2.4 - Soil Core Chemical Sample Collection Procedure describes the soil sampling procedure for chemical analysis, once a soil core is recovered from a direct-push sampler.

2.4 Soil Core Chemical Sample Collection Procedure

The following describes the collection of soil samples for chemical analysis from a split-spoon soil core, Shelby tube soil core, or direct-push sample core. Form FMG 6.1-01 - Soil Sample Selection Details shows the soil sample selection details. Sample preparation and selection is as follows:

- Record soil core recovery and soil stratigraphy data.
- Discard upper and lower ends of sample core (3 inches ±).
- If clayey soils are present use a precleaned stainless steel knife to cut the remaining core longitudinally, alternatively if sandy soils are present, use a clean stainless steel spoon to scrape away the soil surface.
- Screen the exposed soil surface with a PID to monitor for the presence of volatile organics.

- With a sample knife or spoon, remove soil from the center portion of the core and place in the sample jar (when only one aliquot is required), or when more than one aliquot is required place soils in a precleaned stainless steel bowl for homogenization.
- Do not sample large stones and natural vegetative debris.
- Homogenize the soil and place directly into the sample jars.
- Place collected samples on ice or cooler packs in laboratory-supplied shipping coolers.

When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for volatile organic compounds analyses shall not be mixed.

Exception is noted for the collection of VOCs which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected in triplicate using an EnCore Sampler™ (triplicate samples collected per manufacturers instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

3. TEST PIT SOIL SAMPLE COLLECTION

Subsurface soil samples from a test pit are usually "grab samples", used to characterize the soil at a specific depth or depth interval (e.g., 2 to 4 feet). On occasion, composite samples are collected from a test pit over a greater depth interval (e.g., 5 to 15 feet) to characterize a soil or fill horizon.

Soil samples can be collected from the soils within the backhoe/excavation bucket or from the test pit excavation face (only after the safety concerns identified below have been addressed). Samples that require a discrete depth interval should be collected from the excavation face. Samples are procured using a cleaned steel trowel, shovel, or stainless steel spoon.

Safety Concerns:

1. *Do not enter the test pit unless Confined Space Entry requirements have been reviewed and applied (if required); and proper shoring of the excavation walls has been performed, (if necessary.)*

2. *Personnel observing or sampling test pit operations must never stand within the "turning radius" or "reach-zone" of the excavation equipment. Operator error, or equipment failure could result in severe injury or death if struck by the backhoe bucket or the backhoe itself.*
3. *Lastly, personnel should be alert to test pit side wall conditions which typically undermine the ground surface and create unstable soils surrounding the test pit area.*

The following describes the collection of grab samples for chemical analysis:

- Record soil stratigraphy and test pit data/observations, select area from which sample is required.
- Direct backhoe operator to scoop up soils from the desired area and place at ground surface.
- If clayey soils are present use a precleaned stainless steel knife to scrape away the surface soils that may have contacted the backhoe bucket; alternatively, if sandy soils are present, use a clean stainless steel spoon to scrape away the soil surface.
- Screen the exposed soil surface with a PID to monitor for the presence of volatile organics.
- With a sample knife or spoon, remove soil from the center portion of the area cleared and place in the sample jar (when only one aliquot is required), or when more than one aliquot is required place soils in a precleaned stainless steel bowl for homogenization.
- Do not sample large stones and natural vegetative debris.
- Homogenize the soil and place directly into the sample jars.
- Place collected samples on ice or cooler packs in laboratory supplied shipping coolers.

When only one sample container is required, the collected soil will be placed directly into the clean, pre-labeled sample jar. When more than one sample container requires filling or samples will be split for duplicate analyses; the soils will first be homogenized in a precleaned stainless steel bowl; and then placed into the respective sample containers. It is important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. When round bowls are used for sample mixing, mixing is achieved by stirring the material in a circular motion and occasionally turning the material over. Soil samples collected for VOC analyses shall not be mixed.

Exception is noted for the collection of VOCs which require special sample collection methods. VOCs are collected directly into a sample vial (triplicate volume typically required) without headspace, or collected in triplicate using an EnCore Sampler™ (triplicate samples collected per manufacturers instructions). Samples for VOCs are typically collected first, without homogenization or extra handling to limit the loss of volatile constituents.

The VOC sample collection methodology will be identified in the Work Plan, which will dictate the sample method. The methodology for VOC sampling varies from area to area, so carefull review of this issue in advance of the field efforts is required.

Field Notes

All conditions at the time of sample collection should be properly documented in the field log book. This should include a thorough description of the collection method, sample characteristics, including grain size, color, and general appearance, as well as date/time of sampling and labeling information. The location of the sampling point should be described in a sketch and three measurements (swing ties) should be taken to adjacent permanent structures so that the sample location can be readily identified in the field at a future date if necessary. It is often advisable to have a licensed land surveyor accurately survey the locations.

Decontamination

In all sampling scenarios measures to prevent cross-contamination must be employed. The sampling device selected must be constructed of an inert material with smooth surfaces that can be readily cleaned (see FMG 9.0 - Equipment Decontamination).

Heavy equipment used for test pit operations must also be cleaned between each location when collecting samples for chemical analysis.

EQUIPMENT/MATERIALS

- Drilling equipment and soil sampling tools.
- Decontamination fluids and rinse water.
- Subsurface boring log.
- Tape measure.
- Water level probe.

REFERENCES

ASTM D1452-80 - Practice for Soil Investigation and Sampling by Auger Borings.

ASTM D1586-84 - Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D1587-94 - Practice for Thin Walled Tube Geotechnical Sampling of Soils.

ASTM D2488-93 - Practice for Description and Identification of Soils (Visual-Manual Procedure).

ASTM D4700-91 - Guide for Soil Sampling from the Vadose Zone.

Environmental Protection Agency (1986), RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

Environmental Protection Agency (1987), A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001.

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FMG 3.7-01 WELL DEVELOPMENT AND STABILIZATION FORM

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 3.7
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: NOVEMBER 20, 2001
GENERAL MOTORS LLC	
REVISION NO.: 1	REVISION DATE: APRIL 14, 2003

WELL DEVELOPMENT

INTRODUCTION

This procedure is for the development of groundwater monitoring wells that have been installed in overburden, top of bedrock, or deep bedrock formations. Before a newly constructed well can be used for water quality sampling, measuring water levels, or aquifer testing, it must be developed. Well development refers to the procedure used to clear the well and formation around the screen of fine-grained materials (sands, silts, and clays) produced during drilling or naturally occurring in the formation.

Well development is completed to remove fine grained materials from the well but in such a manner as to not introduce fines from the formation into the sand pack. Well development continues until the well responds to water level changes in the formation (i.e., a good hydraulic connection is established between the well and formation) and the well produces clear, sediment-free water to the extent practical.

PROCEDURES REFERENCED

- FMG 3.2 - Overburden Wells.
- FMG 3.3 - Bedrock Wells.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

The well development procedures presented below are the recommended standards. However, due to variations in conditions, changes in these standards may be necessary in order to facilitate successful monitoring well development.

Well development can be accomplished by using in-place pumps or by using portable equipment; either peristaltic, bladder, or other appropriate pumps depending on well depth. In the case of developing wells installed utilizing the mud rotary methods (least preferred method) it would be beneficial to surge the well prior to and during development to help break down the filter cake that may have built up on the well screen.

- Don appropriate safety equipment.
- All equipment used for development purposes entering each monitoring well will be cleaned using a soapy wash (laboratory grade), tap water rinse, isopropyl alcohol rinse (or other rinse agent that is appropriate for site-specific conditions), and distilled/deionized water rinse.
- Uncap well and allow water level to stabilize. Attach appropriate pump and lower tubing into well.
- Turn on pump. If well runs dry, shut off pump and allow to recover.
- Collect the groundwater sample in a glass jar to determine relative turbidity, and measure and record the temperature, pH, turbidity, and specific electrical conductance.
- The above steps will be repeated until groundwater is relatively silt-free; no further change is noted; the temperature, pH, turbidity, and specific conductance readings have stabilized to within 10 percent.
- The time period between development and groundwater sampling will be dependent upon the project objectives, and the chemicals of concern (COCs). When sampling for COCs sensitive to turbidity presence (i.e., SVOCs, PCBs, metals), an extended time period between the development activity and the sampling event will be observed. On REALM/ENCORE sites sampling will be conducted in accordance with the following:

Primary COC	***Time Period Between Development and Sampling***
General Chemistry	24 hours
VOCs	24 hours
SVOCs, PCBs, Metals	2 weeks

Waste Disposal

- All waste generated will be disposed in accordance to the methods and procedures contained in FMG 10.0 - Waste Characterization.
- All water generated during cleaning and development procedures will be collected and contained in accordance to the site-specific disposal requirements.
- Personal protective equipment, such as gloves, disposable clothing, and other disposable equipment, resulting from personnel cleaning procedures and from soil sampling and handling activities, will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

EQUIPMENT/MATERIALS

- Appropriate health and safety equipment.

- Knife.
- Power source (e.g., generator, battery).
- Field book.
- Form FMG 3.7-01 - Well Development and Stabilization Form.
- Well keys.
- Graduated pails.
- Pump and tubing.
- Cleaning supplies (including non-phosphate soap, buckets, brushes, laboratory-supplied distilled/deionized water, tap water, isopropyl alcohol or other site-specific rinse agent (e.g., nitric acid solution), aluminum foil, plastic sheeting, etc.).
- Water level meter.
- pH/temperature/conductivity meter.
- Turbidity meter.
- Clear glass jars (e.g., drillers' jars).

REFERENCES

Environmental Protection Agency (1986), RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

Environmental Protection Agency (1987), A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001.

Environmental Protection Agency (1988), Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004.

WELL DEVELOPMENT AND STABILIZATION FORM

PROJECT NAME: ____________________ PROJECT NO.: __________

DATE OF WELL DEVELOPMENT: ____________________

DEVELOPMENT CREW MEMBERS: ____________________

PURGING METHOD: ____________________

SAMPLE NO.: ____________________

SAMPLE TIME: ____________________

WELL INFORMATION

WELL NUMBER: ____________________

WELL TYPE (diameter/material) ____________________

MEASURING POINT ELEVATION: ____________________

STATIC WATER DEPTH: ____________________ ELEVATION: __________

BOTTOM DEPTH: ____________________ ELEVATION: __________

WATER COLUMN LENGTH: ____________________

SCREENED INTERVAL: ____________________

WELL VOLUME: ____________________

Note: For 2-inch diameter well: 1 foot = 0.14 gallons (Imp) or 0.16 gallons (US)
1 meter = 2 liters

	UNITS	*1*	*2*	*3*	*4*	*5*	*TOTAL/ AVERAGE*
VOLUME PURGED (volume/total volume):							
FIELD pH:							
FIELD TEMPERATURE:							
FIELD CONDUCTIVITY:							
CLARITY/TURBIDITY VALUES:							
COLOR:							
ODOR:							
COMMENTS:							

COPIES TO: ____________________

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FMG 5.2-01 SLUG TEST DATA REPORT

REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 5.2
WORLDWIDE FACILITIES GROUP	EFFECTIVE DATE: SEPTEMBER 16, 2002
GENERAL MOTORS LLC	
REVISION NO.: 1	REVISION DATE: NOVEMBER 12, 2002

IN SITU HYDRAULIC CONDUCTIVITY (SLUG TEST) PROCEDURE

INTRODUCTION

This procedure describes the protocol for performing in situ hydraulic conductivity (slug) tests, including preparation, collection of valid field data, and preliminary evaluation of the data.

A slug test is performed to assess the horizontal hydraulic conductivity of a water-bearing zone. Slug tests are accomplished by stressing the screened water-bearing zone through an instantaneous displacement (with a slug) (or removal of water with a bailer) and subsequently measuring and recording the water level response in the well versus time. If the removal of the slug or bailer does not result in the well recovering more than 5 percent of the "90 percent recovery time", then it is considered an "instantaneous" displacement.

Slug testing in select monitoring wells will be performed after the wells have been installed and developed as covered in the Work Plan. Slug testing data will be acquired in a manner that provides valid data that can be used to calculate the horizontal hydraulic conductivity of the formation tested.

There are two types of slug tests: falling-head tests and rising-head tests. It is generally preferable to do a rising-head slug test due to a number of potential problems that can arise with falling-head tests (some of these may lead to inaccurate hydraulic conductivity estimates). It is recommended water level measurements should be collected automatically using a datalogger/ pressure transducer system if at all possible, but they may be collected manually using a battery-operated water level measurement probe if necessary.

PROCEDURES REFERENCED

- FMG 3.0 - Monitoring Wells, Pump Wells, and Piezometers.
- FMG 5.1 - Water Level Measurements.
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 9.0 - Equipment Decontamination.
- FMG 10.0 - Waste Characterization.

PROCEDURAL GUIDELINES

A slug test involves rapidly changing the water level in a well and then measuring the water-level response over time. A very quick change in the water level in a well should be effected at the beginning of a slug test using one of several methods:

- Preferably by inserting or withdrawing a solid or sealed object with an appropriate overall density.
- By changing the air pressure in a well (only when a pressure transducer is used).
- Only if absolutely necessary, adding or removing a slug of water (bailer).

The method chosen will depend on project needs, equipment availability, water disposal/ treatment options, pertinent laws and regulations, and operator experience.

The protocols that follow assume that a person effectively can perform one of the above methods for rapidly changing the water level in a well at the start of a slug test, and can then use either a manual or automatic procedure for measuring water level response over time.

Considerations

Certain activities should be avoided in slug testing. In general, a person should **not** conduct any type of slug testing in a well if:

- The well contains a pipe, a tube, or an obstruction in a depth range where the water level would change.
- The casing diameter in a well varies in the depth range where the water level would level change.
- The water level in a well has not yet recovered to nearly static conditions (e.g., 95 percent or more) after a prior disturbance (e.g., drilling, purging, development, previous well testing, etc.).
- Non-aqueous phase liquid (NAPL) is present in a well.

A ***rising-head*** test should generally **not** be conducted:

- By bailing multiple times, rather than creating an instantaneous water level change.
- By pumping to remove water, unless the amount of water to be removed by the pump can be removed nearly instantaneously and any backflush can be eliminated.
- By using bailers. If bailers must be used, avoid:
  - using a bailer that has a leaky check valve, or

- using a bailer with a diameter so close to that of the casing that groundwater is suctioned into the well while the bailer is raised.

- If the slug cannot be removed nearly instantaneously (e.g., if removal takes over 5 percent of the 90 percent recovery time).

Falling-head tests are generally **not** recommended due to inherent problems associated with reproducibility, the introduction of fluids, and general application restrictions. They are recommended in circumstances when no other option is available. Consult with the Project Manager or an experienced hydrogeologist before undertaking a falling-head test program. Note: Under no circumstances should a falling-head test be performed in a well where the static water level is within the screened section of the well.

Field Documentation

The following data should be obtained prior to heading into the field and/or in the field during slug testing and recorded appropriately (e.g., on Form FMG 5.2-01 - Slug Test Data Report), in a field book, and/or onto an electronic form copied to computer disk):

- Client name.
- Site name.
- Testing company.
- Name of tester.
- Date and time of test.
- Well number.
- Well location.
- Well casing, screen and borehole diameters.
- Well open hole section diameter.
- Total depth of well.
- Any unusual well, weather, or hydrologic features or conditions.
- Top-of-riser distance above ground surface.
- Test procedure used (slug, pneumatic, etc.).
- Transport and disposal methods for any water removed.
- Well drilling method (hollow-stem auger, mud rotary, etc.).
- Decontamination procedures.
- Problems and solutions to problems encountered during testing.
- Static water level.

Other information needed for proper slug-test data interpretation includes:

- Depth interval of screen or open section in well.
- Sandpack porosity (if water levels intersect screen).
- Sandpack diameter (if water levels intersect screen).
- Stratigraphic horizon materials and elevations.
- Hydraulic conductivity of bounding low hydraulic conductivity units, if present.
- Ground surface elevation.

Testing

The steps for conducting a slug test are as follows. An attempt to utilize dataloggers to collect water level measurements should be made if at all possible. Manual measurements should only be used if absolutely necessary but can, and should, be used to collect backup data. The steps for conducting a slug test using automatic water level measurements are as follows:

1. Conduct a review of the Work Plan and the Health and Safety Plan with the project field supervisor, and plan, as needed, for notifications to responsible parties and for site access.
2. Gather equipment needed and inspect for operation.
3. Decontaminate all necessary equipment before entering a site and between each well or as required in the Work Plan or in accordance with FMG 9.0 - Equipment Decontamination, if different.
4. Measure and record the static water level (SWL) in the well to be tested, the depth to bottom, and record whether the bottom is a hard or soft (silty) base.
5. Test the pressure transducer and data logger, and obtain well-bottom and SWL pressures, using the following steps:
   - Place the pressure transducer at least several feet below the top of water as well as below the projected depth of the lowest part of the slug to be used.
   - Make pressure readings until three uniform values are read consecutively.
   - Raise the datalogger 1 foot from its original position. View the pressure reading to confirm that the change in position was accurately reported by the transducer. Repeat the procedure, if required, lowering the transducer a greater distance and again confirming the readings.
   - Return the transducer to its original position and secure the suspension cable to the well casing. Again, make pressure readings until three uniform values are read consecutively. Compare with the original readings to make sure no drift occurs.

6. Perform the following pre-test activities if a rising-head test is to be performed:

   - Allow the slug that will be used to move slowly down into the groundwater. If possible, fully immerse the slug. If there is not enough water in the well for the slug to be fully immersed, then let the bottom of the slug gently come to rest on the well bottom if a hard base can be confirmed, or in the case of a soft well base, enough above the well bottom to avoid immersion in silt. For bailers, prevent agitation of sediment on the bottom of the well as sediment in the bailer may keep the check valve from properly sealing. Ensure that the slug will not bind with the transducer cable and cause the transducer to move.
   - Measure falling pressures during recovery using the pressure transducer until the water level in the well re-equilibrates to near-static conditions (95 percent recovery).
   - Set the pressure transducer below the base of the immersed slug.

7. Start the slug test by creating a nearly instantaneous displacement in water level:

   - For a ***rising-head*** test:
     - Pull the slug rapidly upwards, either remove it from the well (preferred), or secure/suspend it within the well several feet above the SWL if conditions prohibit removing it (for example, significant depth to water coincides with taking manual water level measurements). When using a bailer ensure, upon retrieving the bailer to the surface, that it is not leaking and contains the appropriate volume of water (full if entirely immersed, etc.).
     - Simultaneously pull slug and initiate the datalogger, beginning the measuring/ recording of rising water levels in the well at the predetermined time frequencies (a logarithmic time scale is usually employed).
     - If a bailer is used, listen for cascading water while the bailer is being raised or is suspended, a sign of check valve failure; if failure occurs, clean and repair the valve and start over.
     - If a bailer is used, measure the volume of water removed by the bailer after retrieval.
   - For ***falling-head*** tests, if employed, prepare the test in the same manner as for the rising-head test, but instead add a solid slug or a known volume of water as opposed to removing a slug or bailer of water.

8. Continue measuring the water levels as they change over time until the water in the well rises or falls to the limit specified in the Work Plan (if not specified then usually 90 percent recovery or 1 hour, whichever comes first (check with Project Manager to be sure). A preset logarithmic sampling interval, with increasing intervals of time, is ideal, usually predetermined by the datalogger's default setup. Check the datalogger to ensure data were collected.

9. Compare the volume of groundwater recovered in the bailer, if one is used, with the volume of groundwater estimated to have been removed from the well (V) based on the

initial recorded water level displacement (H) and borehole radius (r), e.g., $V=H\pi r^2$. If, for a rising-head test, the static water level lies within the screened section of the well, then the sandpack porosity (n) and radius (R) must accounted for also in the volume calculation, e.g., $V=H\pi r^2 + nH\pi(R-r)^2$. A similar comparison can be performed if a slug is used. If the volume recovered and the calculated volume do not reasonably correlate, based on site-specific conditions, the test should be performed again.

10. Record all general data in a field book and all pertinent testing data on Form FMG 5.2-01 - Slug Test Data Report.
11. Decontaminate all necessary equipment in accordance with the Work Plan or methods described in FMG 9.0 - Equipment Decontamination.
12. Properly containerize and label spent decontamination fluid or groundwater removed from the well in accordance with the Work Plan or methods described in FMG 10.0 - Waste Characterization.
13. Lock all well caps and secure the site as needed.
14. Submit the slug test data to a qualified scientist or engineer assigned by the Project Manager for interpretation. The data should be interpreted by an experienced hydrogeologist. Calculations should be based on an appropriate model for the known hydrogeologic conditions in the field. Evaluation of slug test data should be performed using an acceptable analytical method; GM preference is that slug tests be evaluated using either the Bouwer and Rice (1976) or Hvorslev (1951) method.

Any variations from these procedures should first be approved by the project field supervisor and/or Project Manager.

EQUIPMENT/MATERIALS

- A battery-operated water level measurement probe, marked in 0.01-foot increments.
- Form FMG 5.2-01 - Slug Test Data Report.
- Data logger and laptop computer with fully charged battery (if required).
- A solid or sealed slug (or a clean bailer).
- Clean rope or string for raising and lowering a slug.
- Appropriate container for withdrawn groundwater and/or decontamination fluids.
- If snow or soil removal from over a well might be required, a shovel.
- Site-access and well-cap keys, as needed.
- Site maps (property lines, wells, topography, etc.), as needed.
- If a well to be slug tested is an artesian flowing well, duct tape, couplings, and extra casing of appropriate diameter for increasing casing height so as to enable measurement of a static water level.

- Pressure transducer of appropriate pressure range for the depths of water to be tested, if needed.

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FMG 5.1-01 GROUNDWATER LEVEL MONITORING REPORT

WATER LEVEL MEASUREMENTS

INTRODUCTION

This procedure describes measurement of water levels in groundwater monitoring and extraction wells, piezometers and boreholes. This procedure does not cover automated measurement of water levels with a transducer/datalogger, and does not cover measurement of phase-separated liquids.

Water levels in monitoring wells will be measured prior to each sampling event and at other times as indicated in the project Work Plan. Water levels will be acquired in a manner that provide accurate data that can be used to calculate vertical and horizontal hydraulic gradients and other hydrogeologic parameters. Accuracy in obtaining the measurements is critical to insure the useability of the data.

PROCEDURES REFERENCED

- FMG 6.5 - Non-Aqueous Phase Liquid (NAPL).
- FMG 8.0 - Field Instruments – Use/Calibration.
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

In order to provide reliable data, water levels must be collected over as short a period of time as practical. Barometric pressure can affect groundwater levels and, therefore, observation of significant weather changes during the period of water level measurements must be noted. Tidal fluctuations, navigation controls on rivers, rainfall events, and groundwater pumping can also affect groundwater level measurements. Personnel collecting water level data must note if any of these controls are in effect during the groundwater level collection period. Due to possible changes during the groundwater level collection period, it is imperative that the time of data collection at each station be accurately recorded.

In conjunction with groundwater level measurements, surface water (e.g., ponds, lakes, rivers, and lagoons) often are monitored as well. This information is very helpful (and can be critical) in understanding the hydrogeologic setting of the site and most importantly how contaminants may move beneath the site.

The depth to groundwater will be measured with an electronic depth-indicating probe. Prior to obtaining a measurement, a fixed reference point on the well casing shall be established for each well to be measured. Unless otherwise established, the reference point is typically established and marked on the north side of the well casing. Avoid using protective casings or flush-mounted road boxes for reference, due to the greater potential for damage or settlement.

If provided for in the project Work Plan, the elevation of the reference point shall be obtained by accepted surveying methods, to the nearest 0.01 foot.

The water level probe will be lowered into the well until the meter indicates (via indicator light or tone) the water is reached. The probe will be raised above water level and slowly lowered again until water is indicated. The cable will be held against the side of the inner protective casing at the point designated for water level measurements and a depth reading taken. This procedure will be followed three times or until a consistent value is obtained. The value will be recorded to the nearest 0.01 foot on Form FMG 5.1-01 - Groundwater Level Monitoring Report or other designated data recording location if specified in the project Work Plan.

Upon completion, the probe will be raised to the surface and together with the amount of cable that entered the well casing, will be decontaminated in accordance with methods described in FMG 9.0 - Equipment Decontamination.

EQUIPMENT/MATERIALS

- Battery-operated, non-stretch electronic water level probe with permanent markings at 0.01-foot increments (traceable to national measurement standards), such as the Solinst Model 101 or equivalent.
- The calibrated cable on the depth indicator will be checked against a surveyor's steel tape once per quarter year. A new cable will be installed if the cable has changed by more than 0.01 percent (0.01 foot for a 100-foot cable). See also FMG 8.0 - Field Instruments – Use/Calibration.

REFERENCES

ASTM D4750 - Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).

ASTM D6000 - Guide for Presentation of Water-Level Information from Ground-Water Sites.

Form FMG 5.1-01

GROUNDWATER LEVEL MONITORING REPORT

WELL NUMBER

Page ____ of ____

PROJECT ____________________ PROJECT MANAGER ____________________

LOCATION ____________________ FIELD REP. ____________________

CLIENT ____________________ DATE ____________________

ELEVATION REFERENCED TO: ____________________

Date	Time	Elapsed Time (days)	Depth of Water from ( ) in ft	Elevation of Water	Remarks	Read By

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

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FMG 6.4-02 SAMPLE COLLECTION DATA SHEET

FMG 6.4-03 MONITORING WELL RECORD FOR LOW-FLOW PURGING

GROUNDWATER SAMPLING

INTRODUCTION

This procedure is for the collection of groundwater samples for laboratory analysis.

The objective of most groundwater quality monitoring programs is to obtain samples that are representative of existing groundwater conditions, or samples that retain the physical and chemical properties of the groundwater within an aquifer.

One of the most important aspects of groundwater sampling is acquiring samples that are free of suspended silt, sediment, or other fine grained particulates. Fine grain materials may often have a variety of chemical components sorbed to the particle or have the ability to sorb chemicals from the aqueous phase to the particle which will bias the subsequent analytical results.

Constituents known to have an affinity for fine grained particulates are: polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and inorganics. Monitoring programs where these constituents are suspected or known to be prevalent must employ sampling methods that minimize particulate presence.

The sampling method of "preference" for GM sites where particulate sorption is an issue is the "low stress/low flow" technique described within this FMG. Experience has shown that the "low stress/low flow" technique typically achieves representative groundwater samples with minimal particulate interference. In addition to the "low stress/low flow" technique, a "typical sample method" has been presented for the collection of constituents less sensitive to particulates presence (i.e., VOCs), or "direct-push sample methods" generally employed as a "pre-screening tool" to evaluate VOC presence. Direct-push sample procedures will result in groundwater samples with particulates present.

Lastly, in "extreme" cases "ultra-low flow" techniques have been employed at select sites where "low stress/low flow" methods were used, yet particulate-sensitive constituents continue to bias the analytical results. Ultra-low flow techniques are conducted at purging rates below 100 mL per minute, and should only be utilized after careful review and a procedural variance has been approved.

PROCEDURES REFERENCED

- FMG 1.4 - Data Recording - Field Books/Digital Recording.
- FMG 5.1 - Water Level Measurements.
- FMG 8.0 - Field Instruments - Use/Calibration
- FMG 9.0 - Equipment Decontamination.

PROCEDURAL GUIDELINES

The following describes three techniques for groundwater sampling: "Low Stress/Low Flow Methods", "Typical Sample Methods", and "Direct-Push Methods".

"Low Stress/Low Flow Methods" will be employed when it is critical to collect groundwater samples truly representative of the groundwater present, and to minimize the impact of sediment/colloid presence. Analysis typically sensitive to turbidity/sediment issues are PCBs, SVOCs, and inorganic constituents.

The "Typical Sample Methods" will be employed where the collection of parameters less sensitive to turbidity/sediment issues are being collected (VOCs and general chemistry).

The "Direct-Push Methods" are typically employed for pre-screening areas for chemical presence to aid in determining well placement, or the need for further study.

Note: If non-aqueous phase liquids (NAPL) (light or dense) are detected in a monitoring well, groundwater sample collection will not be conducted and the Project Manager must be contacted to determine a course of action.
If deemed necessary to sample groundwater from below a LNAPL layer, a suggested sampling procedure has been presented at the end of this Procedural Guidelines section.

Preparatory Requirements

- Verify well identification and location using borehole log details and location layout figures. Note the condition of the well and inform the Project Manager of any required repair work.
- Prior to opening the well cap, measure the breathing space above the well casing with a PID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the Health and Safety Plan, field personnel should adjust their PPE accordingly.
- Prior to commencing the groundwater purging/sampling tasks, water level and total well depth measurements must be obtained to determine the volume of water in the well. Refer to

FMG 5.1 - Water Level Measurements for details. In some settings it maybe necessary to allow time for the water level to equilibrate. This condition exists if a water tight seal exists at the well cap and the water level has fluctuated above the top of screen; creating a vacuum or pressurized area within the well casing. Three water level checks will verify static water level conditions or changing conditions.

- Calculate the water volume in the well. Typically overburden well volumes consider only the quantity of water standing in the well screen and riser; bedrock well volumes are calculated on the quantity of water within the open corehole and within the overburden casing.
- Estimate the natural groundwater flow rate into well to determine the approximate pumping rate for purging/sampling activities.

Well Purging and Stabilization Monitoring (Low Stress/Low Flow Method)

- The GM method of preference for groundwater sampling will be the low stress/low flow method described below.
- Bladder pumps/submersible variable rate pumps (i.e., Grundfos™ Rediflo or equivalent) or peristaltic pumps are typically employed.
- Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified by the project requirements. The pump or tubing should be placed in the well as early as possible before sampling is initiated (this is to minimize well disturbance). In some programs it may be necessary to install the pumping equipment/tubing approximately 24 hours prior to purging. Peristaltic tubing placement should include a tubing "clamp" at the well head, to minimize vibration transfer into the water column. The pump or tubing intake must be at the mid-point of the well screen to prevent disturbance and resuspension of any sediment in the screen base. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project Work Plan.
- Before starting the pump, measure the water level again with the pump in the well leaving the water level measuring device in the well when completed.
- Purge the well at 100 to a maximum of 500 milliliters per minute (mL/min). During purging, the water level should be monitored approximately every 5 minutes, or as appropriate. A steady flow rate should be maintained that results in drawdown of 0.3 feet or less. The rate of pumping should not exceed the natural flow rate conditions of the well being sampled. Care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record adjustments made to the pumping rates and water levels immediately after each adjustment.
- Calibrate field instrument and document calibration activity. Calibration shall be performed in accordance with manufacturer's recommendations and FMG 8.0 - Field Instruments - Use/Calibration.

- During the purging of the well, monitor and record the field indicator parameters (pH, temperature, conductivity, oxidation-reduction (redox) reaction potential (ORP), dissolved oxygen (DO), and turbidity) approximately every 5 minutes. Stabilization is considered to be achieved when the final groundwater flow rate is achieved, and three consecutive readings for each parameters are within the following limits:
  - pH ±0.1 pH units of the average value of the three readings;
  - temperature ±3 percent of the average value of the three readings;
  - conductivity ±0.005 milliSiemen per centimeter (mS/cm) of the average value of the three readings for conductivity <1 mS/cm and ±0.01 mS/cm of the average value of the three readings for conductivity >1 mS/cm;
  - ORP ±10 millivolts (mV) of the average value of the three readings;
  - DO ±10 percent of the average value of the three readings; and
  - turbidity ±10 percent of the average value of the three readings, or a final value of less than 5 nephelometric turbidity units (NTU).
- Should stabilization not be achieved for all field parameters, purging is continued until a maximum of 20 well screen volumes have been purged from the well. Since low-flow purging (LFP) likely will not draw groundwater from a significant distance above or below the pump intake, the screen volume is based upon a 5-foot (1.4 m) screen length. After purging 20 well screen volumes, purging is continued if the purge water remains visually turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization.
- If low-turbidity samples are critical to the project goals, purging will be extended until turbidity has been reduced to 5 NTU or less.
- The pump must not be removed from the well between purging and sampling.

Well Purging and Stabilization Monitoring (Typical Method)

- Typically peristaltic pumps or bladder pumps or submersible pumps are preferred. In most cases bailer use is not desirable due to the "surging" action of bailer entry and removal. Exception is noted for VOC sampling where bailers are often used.
- The pump intake/tubing is typically placed at the mid-point of the screen within overburden wells. Bedrock well sampling may require pump/tubing placement in specific fracture zone areas or other areas which will be identified within the project Work Plan.
- Purge the well until three consecutive well volume measurements of temperature and specific conductivity are approximately plus or minus 10 percent and if the pH values are within 1 pH unit of the last three value averages, and the groundwater turbidity values are less than the project Work Plan requirements. If stabilization has not occurred within the first five well volumes removed, continue purging and monitoring until eight well volumes have been pumped. Purging rates should not exceed the natural flow rate of groundwater into the well.

Elevated purging rates may result in excessive drawdown of the water column, introducing sediment/particulate presence.

- Groundwater turbidity may be evaluated by a visual examination for sediment/silt presence or use of a nephlometer. Work Plan-specific goals may exist for turbidity values which may require extending the purging, or require an alternate pumping system.
- Purging and stabilization activities using a bailer are generally performed at the top of the water column, within the riser piping/above the well screen. This will minimize sediment disturbance/suspension in the screen area, and move water from the formation into the well screen/riser area in an effort to remove stagnant groundwater within the well. Bottom-loading bailers are generally employed. The lowering and removal actions are performed slowly to minimize well disturbance. Once stabilization has been attained, the sample aliquots are collected directly from the bailer.
- In the event the well goes dry (poor yielding formations), the purging activities will be performed on 3 consecutive days, noting the field stabilization parameters on each day. After the third day of purging is complete, the sample collection will be performed once sufficient groundwater recharge has occurred.

Direct-Push Sampling Technique

Generally, the direct-push sampling methods are employed for "pre-screening" groundwater quality (typically VOCs) in selected areas. This method is generally used to evaluate the need for permanent monitoring wells, or determine the need for further study. The sampling technique is a direct-push protected-screen sampling technique as described in ASTM D6001 (Standard Guide for Direct Push Water Sampling for Geoenvironmental Investigations). The direct-push sampling technique is summarized as follows:

- Advance borehole to the target depth below the groundwater table.
- Remove the drill rod, assemble the direct–push sample tool and attach it to the drill rod.
- Lower the sample device to the bottom of the borehole using the drill rod.
- Advance the sample device approximately 3 feet into the bottom of the borehole by hydraulically pushing the drill rod.
- Withdraw the drill rods approximately 1 to 2 feet to retract the screen sleeve and to expose the sampler screen to the formation.
- Alternatively a number of direct-push tools exist that do not require an advance borehole, and can be driven directly to the target depth and retracted for sample collection.
- Allow at least 15 minutes from exposing the sampler screen to sample collection to allow silt in the sampler to settle. In tight formations, a longer wait time may be required to allow sufficient groundwater to enter the screen. In some clays the sample device may not collect sufficient water volume to obtain a sample.

- Lower a small bailer into the sampler, discard initial bail (to acclimate bailer), and collect a water sample. A few bailer volumes may be required to obtain a sufficient volume of water sample. Alternatively, a "Waterra" check ball affixed to tubing or a peristaltic pump may be employed to collect a groundwater sample, if allowed by the regulatory agency providing oversight.
- Remove and clean the sampler device after completion of sample collection. Decontaminate sampler for next sample event.

This sampling technique is prone to sediment presence due to the lack of a screen sandpack and the limited purging performed before sample collection. A project variance will be required if non-VOC constituents are being considered for analysis.

Sampling Techniques

- If an alternate pump is utilized (i.e., typical method), the first pump discharge volumes (or bailer volumes) should be discarded to allow the equipment a period of acclimation to the groundwater.
- Samples are typically collected directly from the pump with the groundwater being discharged directly into the appropriate sample container. Avoid handling the interior of the bottle or bottle cap and don new gloves for each well sampled to avoid contamination of the sample.
- Order of sample collection:
  - VOCs;
  - SVOCs and PCBs;
  - Total organic carbon (TOC);
  - Total organic halogens (TOX);
  - Extractable organics;
  - Total metals;
  - Dissolved metals;
  - Phenols;
  - Cyanide;
  - Sulfate and chloride;
  - Nitrate and ammonia; and
  - Radionuclides.
- For low stress/low flow sampling, samples should be collected at a flow rate between 100 and 250 mL/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 feet.
- The pumping rate used to collect a sample for VOCs should not exceed 100 mL/min. Samples should be transferred directly to the final container 40 mL glass vials completely

full and topped with a teflon cap. Once capped the vial must be inverted and tapped to check for headspace/air presence (bubbles). If air is present the sample vial will be discarded, and re-collected until free of air.

- Field filtration will be performed if dictated by the project Work Plan. Sediment presence can interfere or bias sample results; false positive findings have been observed when turbid samples for hexavalent chromium (and other analytes) are analyzed. Field filtration can eliminate this concern; generally applicable to only inorganic/PCB analysis. In-line disposable filter cartridges are generally the easiest and quickest method for field filtration.
- Sample labels/sample identification. All samples must be labeled with:
  - A unique sample number;
  - Date and time;
  - Parameters to be analyzed;
  - Project Reference ID; and
  - Sampler's initials.
- Labels should be secured to the bottle(s) and should be written in indelible inks.

Groundwater Sampling Techniques Below LNAPL Layers

Sampling and analysis of groundwater below a LNAPL layer is typically discouraged, and not performed at REALM/ENCORE sites. The rationale for avoiding groundwater analysis below a LNAPL layer is as follows:

- The potential for sample "contamination" with a trace amount of NAPL is very possible; analytical data will be biased "high" based upon this concern.
- Analytical data generated from this scenario does not represent "dissolved" constituent presence in groundwater. Dissolved constituents are "best" determined in downgradient locations.

In some instances sampling and analysis of groundwater collected below a LNAPL layer may be required, possibly at the request of a regulatory group. If absolutely necessary, this type of sampling may be accomplished in accordance with the following:

- Determine the LNAPL depth and thickness using an interface probe or clear bottom loading bailer.
- Determine the sampling depth, selecting a sample point as far away as possible from the LNAPL interface.
- Using a "capped" outer tube or piping (i.e., 1-inch diameter polyethylene), insert the outer tube to the selected sample interval. The cap should be a slip-on cap affixed to the outer tube using a short "leash" (i.e., stainless steel wire or equivalent). This allows cap recovery once the sampling is complete.

- Insert the sample line (3/8-inch diameter tubing) into the outer tube and "push out" the end cap for sample line entry into the sampling interval.
- Perform purging and sampling using a peristaltic pump[1] or small diameter bailer.
- Monitor the groundwater level and/or the NAPL level to ensure the LNAPL layer is not drawn to sampling depth. If LNAPL drawdown occurs evaluate the need to proceed further, and consider terminating sampling activity.
- This sample should not be referred to on any analysis as a groundwater sample. It should always be referred to as a groundwater/NAPL mixture (GW/NAPL designation).

EQUIPMENT/MATERIALS

- pH meter, conductivity meter, nephlometer, ORP meter, DO meter, temperature gauge.
- Field filtration units (if required).
- Purging/sampling equipment:
  - Peristaltic pump (may not be suitable for VOCs[1]/SVOCs, or drawing water from depths greater than 25 feet[2]);
  - Suction pumps (not suitable for LFP, VOCs/SVOCs, or depths greater than 25 feet);
  - Submersible pumps (suitable for VOCs/SVOCs only at low flow rates);
  - Air lift pumps (not suitable for VOCs/SVOCs);
  - Bladder pumps (suitable for LFR and VOCs/SVOCs);
  - Inertia pumps (gaining acceptability for VOCs/SVOCs, generally not suited for GM programs); and
  - Bailers.
- Water level probe.
- Sampling materials (containers, log book/forms, coolers, chain-of-custody).
- Project Work Plan.
- Health and Safety Plan.

Note[1]: Peristaltic pump use for VOC collection is acceptable on select EPA/RCRA sites; this technique has gained acceptance in select areas. Where it is permissible to collect VOCs using a peristaltic pump, collection must be performed at a low flow rate (Michigan allows VOC sampling with the peristaltic pump).
Acceptability of the collection of VOCs using the peristaltic pump should be evaluated before the sampling program commences, commonly performed during the project Work Plan development and approval process.

Note[2]: Exception is noted in locations that the suction line can be placed at the desired sample depth (i.e., 100 feet), and the natural recharge maintains a water level within 25 feet of the ground surface.

Field Notes

Field notes must document field activities and measurements collected during the sampling activities. FMG 1.4 - Data Recording - Field Books/Digital Recording describes the data/recording procedure for field activities. The log book/field file should document the following for each well sampled:

- Identification of well.
- PID readings before and after well opening (if required).
- Well depth.
- Static water level depth and measurement technique.
- Sounded well depth.
- Presence of immiscible layers and detection/collection method.
- Well yield – high or low.
- Purge volume, pumping rate, and final disposition.
- Time well purged.
- Measured field parameters and meter calibration records.
- Purge/sampling device used.
- Well sampling sequence.
- Sample appearance.
- Sample odors.
- Sample volume.
- Types of sample containers and sample identification.
- Preservative(s) used.
- Parameters requested for analysis.
- Field analysis data and method(s).
- Sample distribution and transporter.
- Analytical laboratory.
- Chain-of-custody number for shipment to laboratory.
- Field observations on sampling event.
- Name(s) of sampling personnel.

- Climatic conditions including air temperature.
- Problems encountered and any deviations made from the established sampling protocol.

A standard log form for documentation and reporting groundwater purging and sampling events are presented on Form FMG 6.4-01 - Well Purging Field Information, Form FMG 6.4-02 - Sample Collection Data Sheet, and Form FMG 6.4-03 - Monitoring Well Record for Low-Flow Purging.

Groundwater/Decontamination Fluid Disposal

The project Work Plan will identify the required disposal procedures for groundwater and decontamination fluids. Groundwater disposal methods will vary on a case-by-case basis but may range from:

- Off-site treatment at private treatment/disposal facilities or public owned treatment facilities.
- On-site treatment at Facility-operated facilities.
- Direct discharge to the surrounding ground surface, allowing groundwater infiltration to the underlying subsurface regime.
- Direct discharge to impervious pavement surfaces, allowing evaporation to occur.

Decontamination fluids should be segregated and collected separately from wash waters/groundwater containers. Often small volumes of solvents used during the day can be allowed to evaporate if left in an open pail. In the event evaporation is not possible or practical, off-site disposal arrangements must be made.

REFERENCES

ASTM D5474 - Guide for Selection of Data Elements for Groundwater Investigations.

ASTM D4696 - Guide for Pore-Liquid Sampling from the Vadose Zone.

ASTM D5979 - Guide for Conceptualization and Characterization of Groundwater Systems.

ASTM D5903 - Guide for Planning and Preparing for a Groundwater Sampling Event.

ASTM D4448 - Standard Guide for Sampling Groundwater Wells.

ASTM D6001 - Standard Guide for Direct Push Water Sampling for Geo-Environmental Investigations.

USEPA Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (EPA/540/S -95/504).

USEPA RCRA Groundwater Monitoring: Draft Technical Guidance (EPA/530-R-93-001).

WELL PURGING FIELD INFORMATION FORM

JOB# ______ - ___

SITE/PROJECT NAME: ____________________ WELL# ________

WELL PURGING INFORMATION

PURGE DATE (MM DD YY)	SAMPLE DATE (MM DD YY)	WATER VOL. IN CASING (LITRES/GALLONS)	ACTUAL VOLUME PURGED (LITRES/GALLONS)

PURGING AND SAMPLING EQUIPMENT

PURGING EQUIPMENT.........DEDICATED Y N (CIRCLE ONE)

SAMPLING EQIPMENT.........DEDICATED Y N (CIRCLE ONE)

PURGING DEVICE [ ] A - SUBMERSIBLE PUMP D - GAS LIFT PUMP G - BAILER X- ________ PURGING OTHER (SPECIFY)

B - PERISTALTIC PUMP E - PURGE PUMP H - WATERRA®

SAMPLING DEVICE [ ] C - BLADDER PUMP F - DIPPER BOTTLE X- ________ SAMPLING OTHER (SPECIFY)

PURGING DEVICE [ ] A - TEFLON D - PVC X- ________ PURGING OTHER (SPECIFY)

B - STAINLESS STEEL E - POLYETHYLENE

SAMPLING DEVICE [ ] C - POLYPROPYLENE X- ________ SAMPLING OTHER (SPECIFY)

PURGING DEVICE [ ] A - TEFLON D - POLYPROPYLENE F - SILICONE X- ________ PURGING OTHER (SPECIFY)

B - TYGON E - POLYETHYLENE G - COMBINATION TEFLON/POLYPROPYLENE

SAMPLING DEVICE [ ] C - ROPE X- ________ (SPECIFY) X- ________ SAMPLING OTHER (SPECIFY)

FILTERING DEVICES 0.45 [ ] A - IN-LINE DISPOSABLE B - PRESSURE C - VACUUM

FIELD MEASUREMENTS

WELL ELEVATION ________ (m/ft) GROUNDWATER ELEVATION ________ (m/ft)

DEPTH TO WATER ________ (m/ft) WELL DEPTH ________ (m/ft)

pH	TURBIDITY	CONDUCTIVITY	ORP	DO	SAMPLE TEMPERATURE
(std)	(ntu)	(µm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(µm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(µm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(µm/cm) AT 25°C	(mV)	(mg/L)	(°C)
(std)	(ntu)	(µm/cm) AT 25°C	(mV)	(mg/L)	(°C)

FIELD COMMENTS

SAMPLE APPEARANCE: ________ ODOR: ________ COLOR: ________ TURBIDITY: ________

WEATHER CONDITIONS: WIND SPEED ________ DIRECTION ________ PRECIPITATION Y/N OUTLOOK ________

SPECIFIC COMMENTS

I CERTIFY THAT SAMPLING PROCEDURES WERE IN ACCORDANCE WITH APPLICABLE GM PROTOCOLS

DATE ________ PRINT ________ SIGNATURE ________

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

SAMPLE COLLECTION DATA SHEET - GROUNDWATER SAMPLING PROGRAM

PROJECT NAME ______________________ PROJECT NO. __________

SAMPLING CREW MEMBERS ______________________ SUPERVISOR __________

DATE OF SAMPLE COLLECTION ______________________

[Note: For 2" dia. well, 1 ft. = 0.14 gal (imp) or 0.16 gal (us)]

Sample I.D. Number	Well No.	Measuring Point Elev. (ft. AMSL)	Bottom Depth (ft. btoc)	Water Depth (ft. btoc)	Water Elevation (ft. AMSL)	Well Volume (gallons)	Bailer Volume / No. Bails	Volume Purged (gallons)	Field pH	Field Temp.	Field Cond.	Time	Sample Description & Analysis

Additional Comments: ______________________

Copies to: ______________________

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

MONITORING WELL RECORD FOR LOW-FLOW PURGING

Project Data:

Project Name: ____________________ Date: ____________________

Ref. No.: ____________________ Personnel: ____________________

____

Monitoring Well Data:

Well No.: ____________________ Screen Length (ft): ____________________

Measurement Point: ____________________ Depth to Pump Intake (ft)[(1)]: ____________________

Constructed Well Depth (ft): ____________________ Well Diameter, D (in): ____________________

Measured Well Depth (ft): ____________________ Well Screen Volume, V_s (mL)[(2)]: ____________________

Depth of Sediment (ft): ____________________ Initial Depth to Water (ft): ____________________

Time	*Pumping Rate (mL/min)*	*Depth to Water (ft)*	*Drawdown from Initial Water Level[(3)] (ft)*	*pH*	*Temperature ^oC*	*Conductivity (mS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Volume Purged, V_p (mL)*	*No. of Well Screen Volumes Purged[(4)]*

Notes:

(1) The pump intake will be placed at the well screen mid-point or at a minimum of 2 ft above any sediment accumulated at the well bottom.

(2) The well screen volume will be based on a 5-foot screen length, V_s=p*(D/2)^2*(5*12)*(2.54)^3

(3) The drawdown from the initial water level should not exceed 0.3 ft.

(4) Purging will continue until stabilization is achieved or until 20 well screen volumes have been purged (unless purge water remains visually turbid and appears to be clearing, or unless stabilization parameters are varying slightly outside of the stablization criteria and appear to be stablizing), No. of Well Screen Volumes Purged= Vp/Vs.

FMG MODIFICATIONS MUST BE ACCOMPANIED BY A REVISION REQUEST FORM APPROVED BY THE PROJECT MANAGER

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REMEDIATION SECTION	FIELD METHOD GUIDELINE NO.: FMG 6.10
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SAMPLE HANDLING AND SHIPPING

INTRODUCTION

Sample management is the continuous care given to each sample from the point of collection to receipt at the analytical laboratory. Good sample management ensures that samples are properly recorded, properly labeled, not lost, broken, or exposed to conditions which may affect the sample's integrity.

All sample submissions must be accompanied with a chain-of-custody (COC) document to record sample collection and submission.

The following sections provide the minimum standards for sample management.

PROCEDURAL GUIDELINES

Field Handling

Prior to entering the field area where sampling is to be conducted, especially at sites with defined exclusion zones, the sampler should ensure that all materials necessary to complete the sampling are on hand.

If samples must be maintained at a specified temperature after collection, proper coolers and ice/cool-packs must be brought out to the field. Consideration should be given to keeping reserve cooling media on hand if sampling events will be of long duration. Conversely, when sampling in extremely cold weather, proper protection of water samples, trip blanks, and field blanks must be considered.

Personnel performing groundwater sampling tasks must check the sample preparation and preservation requirements to ensure compliance with the Work Plan QAPP. Typical sample preparation may involve pH adjustment (i.e., preservation), sample filtration and preservation, or simply cooling to 4°C. Sample preparation requirements vary from site to site and vary depending upon the analytical method for which the samples will be analyzed.

The sampling personnel must also confirm before the sample event, the amount of bottle filling required for the respective sample containers. VOC samples must not have any headspace within the sample collection vial; whereas when collecting select analytes (i.e., metals) a headspace must be provided to allow addition of the required preservative.

Sample Labeling

Samples must be properly labeled as soon as practical after collection.

Note that the data shown on the sample label is the minimum data required. The sample label data requirements are listed below for clarity.

i) Project name.
ii) Sample number.
iii) Sampler's initials.
iv) Date of sample collection.
v) Time of sample collection.
vi) Analysis required.
vii) Preservatives.

The Work Plan Quality Assurance/Quality Control (QA/QC) specification should be reviewed to determine any additional requirements.

Quite often the analytical laboratory supplying the containers will provide blank sample labels. If these are adequate and convenient they can be used.

Under certain field conditions it is impractical to complete and attach sample labels to the container at the point of sample collection. However, to ensure that samples are not confused, a clear notation should be made on the container with a permanent marker indicating the last three digits of the sample number. If the containers are too soiled or small for marking, the container can be put into a zip-lock bag which can then be labeled.

No one sample number format is adequate for every type of sampling activity. Prior to the start of every project or sub-sampling event within the project, Project Managers and field personnel should devise a sample number format. Sample number formats should be as simple and short as possible. Simple number formats will reduce transcription errors by both Consultants and lab personnel. The sample number format should be comprehensive enough to allow for easy location of detailed sample data within the Site log books. Sample format must also be consistent with any future data management activities.

Unless otherwise instructed, labels should not contain specific names of the sample source (i.e., "Well No. 16"). Provision of such specific data on the label can produce biased lab results.

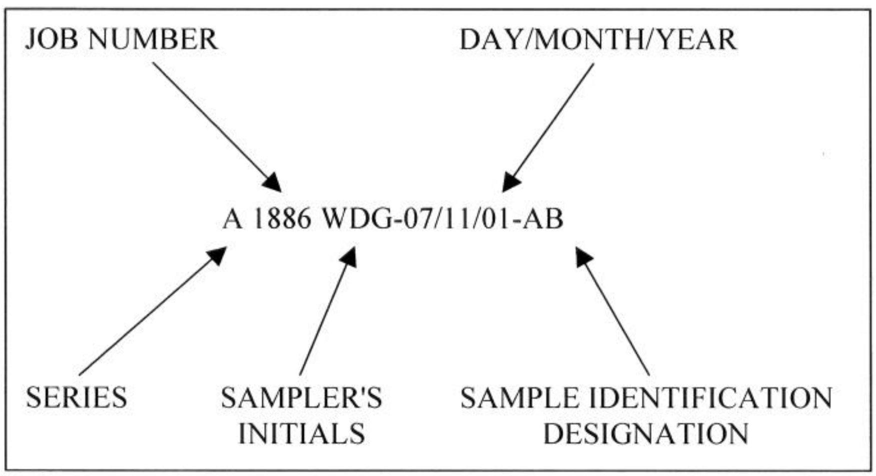
Sample Labels/Sample Identification

All samples must be labeled with:

- A unique sample number (never to be re-used, nor likely to be).
- Date and time.
- Parameters to be analyzed.
- Job number.
- Sampler's initials.

Labels should be secured to the bottle and should be written in indelible inks. It is also desirable to place wide clear tape over the label before packing in a cooler for label protection during transportation.

The unique sample identification number may follow the format recommended below, or a specific sample protocol for labeling may be specified in the project Work Plan.



This format has been selected to maximize the information content of the sample number. Minor modifications are certainly reasonable.

i) Series is a letter which designates a group of samples. This might include sample round, or might designate sample type (e.g., sediment, soil, volatile analysis, Round 2 Lower Aquifer wells), or sample source. For example, "A" might mean samples of influent to some treatment system, "B" might mean samples of effluent. Letters should be used, not numbers. Series is optional.

ii) Job number together with the series number, will allow easier tracking of samples.

iii) Sampler's initials will allow identification of the sampler, and so allow all project personnel to contact the correct person for information regarding that sample and its collection. The use of three initials is requested. Special arrangements will need to be made if two individuals have the same initials.

iv) Sample date will allow monitoring of actual holding time of samples and should ensure that all sample numbers are unique, even if sample location designation is used in a system, as opposed to assigned at random.

v) Sample identification designation will identify the sample, and can be any numerical or letter designation.

The decision of how to assign sample numbers should be made at the beginning of a job or phase, and should be consistent throughout the job.

Packaging

When possible, sample container preparation and packing for shipment should be completed in a well organized and clean area, free of any potential cross-contaminants.

Sample containers should be prepared for shipment as follows:

i) Containers should be wiped clean of all debris/water using paper towels (paper towels must be disposed of with other contaminated materials).

ii) Clear, wide packing tape should be placed over the sample label for protection.

While there is no one "best" way to pack samples for shipment, the following packing guidelines should be followed.

i) Plan time to pack your samples (and make delivery to shipper if applicable). Proper packing and manifesting takes time. A day's worth of sampling can be easily wasted due to a few minutes of neglect when packing the samples.

ii) Always opt for more coolers and more padding rather than crowd samples. The cost associated with the packing and shipment of additional coolers is usually always small in comparison with the cost of having to re-sample due to breakage during shipment.

iii) Do not bulk pack. Each sample must be individually padded.

iv) Large glass containers (1 L and up) require much more space between containers.

v) Ice is not a packing material due to the reduction in volume when it melts.

The following is a list of standard guidelines which must be followed when packing samples for shipment.

i) When using ice for a cooling media, always double bag the ice in zip-lock bags.

ii) Double-check to ensure trip and temperature blanks have been included for all shipments containing VOCs, or where otherwise specified in the QA/QC plan.

iii) Enclose the COC form in a zip-lock bag.

iv) Ensure custody seals (two, minimum) are placed on each cooler. Coolers with hinged lids should have both seals placed on the opening edge of the lid. Coolers with "free" lids should have seals placed on opposite diagonal corners of the lid. Place clear tape over custody seals.

v) Ensure that all "Hazardous Material" stickers/markings have been removed from coolers being used which previously contained such materials.

> *Note: Never store sterile sample containers in enclosures containing equipment which use any form of fuel or volatile petroleum based product. An alternate means of secure storage must be planned for.*
>
> *When conducting sampling in freezing conditions at sites without a heated storage area (free of potential cross contaminants), trip blanks and temperature blanks not being used in a QA/QC role should be isolated from coolers immediately after receipt. Trip and temperature blanks should be double-bagged and kept from freezing.*

Chain-of-Custody

COC forms will be completed for all samples collected. The form documents the transfer of sample containers.

The COC record, completed at the time of sampling, will contain, but not be limited to, the sample number, date and time of sampling, and the name of the sampler. The COC document will be signed and dated by the sampler when transferring the samples.

Each sample cooler being shipped to the laboratory will contain a COC form. The COC form will consist of four copies which will be distributed as follows: The shipper will maintain a copy while the other three copies will be enclosed in a waterproof envelop within the cooler with the samples. The cooler will then be sealed properly for shipment. The laboratory, upon receiving the samples, will complete the three remaining copies. The laboratory will maintain one copy for their records. One copy will be returned to the Field QA/QC Officer upon receipt of the samples by the laboratory. One copy will be returned with the data deliverables package.

COC records are legal documents. They must be completed and handled accordingly.

The following list provides guidance for the completion and handling of all COCs.

i) COCs used should be Consultant standard forms or those supplied by the analytical laboratory. Do not use any COC forms from other labs, even if the heading is blocked out.

ii) COCs must be completed in black ball-point ink only.

iii) COCs must be completed neatly using printed text.

iv) If a simple mistake is made, line out the error with a single line and initial and date next to it.

v) Each separate sample entry must be sequentially numbered.

vi) The use of "Ditto" or quotation marks to indicate repetitive information in columnar entries should be avoided. If numerous repetitive entries must be made in the same column, place a continuous vertical arrow between the first entry and the next different entry.

vii) When more than one COC form is used for a single shipment, each form must be consecutively numbered using the "Page ___ of ___" format.

viii) If necessary, place additional instructions directly onto the COC. Do not enclose separate loose instructions.

ix) Include a contact name and phone number on the COC in case there is a problem with the shipment.

x) Do not indicate the source of the sample as this may produce a biased lab result.

xi) Before using an acronym on a COC, define clearly the full interpretation of your designation [i.e., Polychlorinated Biphenyls - (PCBs)].

Shipment

In all but a few cases the QA/QC plan for the field work will require shipment of samples by overnight carrier. A great many problems can be avoided by proper advance planning.

Prior to the start of the field sampling, the carrier should be contacted to determine if pickup can be made at the field site location. If pickup at the field site can be made, the "no-later-than" time for having the shipment ready must be determined.

If no pickup is available at the site, the nearest pickup or drop-off location should be determined. Again, the "no-later-than" time for each location should be determined.

Sufficient time must be allowed not only for packaging but also for delivery of samples if this becomes necessary. Driving at high rates of speed in order to make the drop time is unacceptable.

Sample shipments must not be left at unsecured or questionable drop locations (i.e., if the cooler will not fit in a remote drop box do not leave the cooler unattended next to the drop box).

Some overnight carriers do not in fact provide "overnight" shipment to/from some locations. Do not assume; call the carrier in advance before the start of the field work.

Copies of all shipment manifests must be maintained in the field file.

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LIST OF FORMS
(Following Text)

FMG 6.14 – 01 Air/Vapor Sampling Form

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SOIL VAPOR MONITORING POINT SAMPLING PROCEDURE

INTRODUCTION

This document includes procedures for sampling soil vapor monitoring points (SVPs) and performing SVP integrity testing. The SVP sampling procedures include the use of SUMMA®-Type Canisters for analysis using USEPA Method TO-15 in situations where achieving low laboratory analytical method detection limits (DLs) is appropriate (e.g., sampling soil gas for vapor intrusion assessments). The procedures also include the use of Tedlar® bags for analysis using USEPA SW-846 Method 8260 in situations where elevated chemical concentrations in soil gas are expected and achieving low DLs or reliable quantitation to support risk assessments is not necessary (e.g., sampling soil gas above free product to evaluate explosivity).

The science and policy of vapor intrusion is a rapidly evolving subject. Scientists are frequently devising new and improved methods and regulatory agencies are frequently updating their guidance documents. Prior to implementing this FMG, updates to federal, state, and local requirements should be evaluated and this FMG should be revised as appropriate.

PROCEDURES REFERENCED

- *FMG 3.10 – Installation Procedure for Soil Vapor Monitoring Points*
- *FMG 9.0 – Equipment Decontamination*
- *FMG-10.0 – Waste Characterization*

EQUIPMENT/MATERIALS

The following equipment and materials are used for the sampling of a soil vapor monitoring point:

1. Appropriate personal protective equipment (PPE) as required by the site specific Health and Safety Plan.

2. Site Plan, Field Sampling Plan, and/or Work Plan, with specific sampling objectives and analytical methods.

3. Sample media, typically consisting of SUMMA®-Type Canisters with pre-calibrated laboratory supplied time integrated flow controllers, pressure gauges, and associated stainless steel Swagelok fittings, ferrules, and "T" apparatus for duplicate sampling. The canisters should be certified clean by the laboratory in accordance with US EPA Method TO-15.

   If elevated chemical concentrations are expected and it is not necessary to achieve low DLs or reliable quantitation to support risk assessment, sample collection may be conducted using Tedlar® bags in conjunction with a vacuum box. The vacuum box allows collection of a soil gas sample directly from the sampling line into a Tedlar® bag without first passing the sample through a pump. This eliminates the potential for cross-contamination from the interior pump components (e.g., rubber diaphragm, filters, gauges, etc.) and the need to disassemble and/or decontaminate the pump after each sample is collected. Two vacuum boxes will be required in instances where field duplicate soil vapor samples are to be collected from a single SVP.

4. Portable vacuum pump.

5. Helium detector.

6. Helium leak testing materials: helium gas, surface testing shroud, Tedlar® bags, sealing agent (i.e. modeling clay), additional nylon tubing for splicing if necessary (typically ¼-inch I.D.).

7. Nylon, Teflon, or stainless steel tubing.

LEAK TESTING

In accordance with both state and federal guidelines (see References below) for sampling soil vapor, it is necessary to perform leak testing on the SVP to insure that ambient air is not being drawn through the surface seal of the SVP (also known as short-circuiting) and that valves and connections do not leak during sample collection. Using helium as an indicator gas, the following steps should be followed to successfully complete leak testing:

- Obtain a surface shroud with two sealed penetrations and a pressure gauge. The surface shroud should have an outside diameter large enough to cover the SVP flush mount opening when it is placed on top of the SVP. It should be noted that there is no standard for the type or configuration of the surface shroud. Any container that can accommodate the components mentioned above, has the capability of being sealed at all openings, and does not introduce contamination or other adverse effects to the SVP or sample quality is an acceptable surface shroud. A container with the smallest possible volume is recommended to reduce the amount of helium that is needed.

- The sample tubing from the SVP that is securely connected to the associated subsurface vapor screen implant is extended using flexible tubing through a sealed penetration in the surface shroud and connected to the purge pump.

<u>Step 1 – Vacuum Test</u>

- The personal sampling pump will be used to conduct the vacuum test. When using SUMMA® canisters, the vacuum test will consist of opening the valve to the personal sampling pump while leaving closed the valves to the SUMMA® canister and the soil gas probe. When using Tedlar® bags with a vacuum box, the vacuum test will consist of connecting the personal sampling pump to the evacuation port of the vacuum box. The vacuum box is then sealed, but absent the Tedlar® bag, with the valves to the vacuum box sampling and evacuation ports open and leaving closed the valve to the soil gas probe. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum, within the sampling assembly), thus establishing that all assembly connections are air-tight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.

- If the pump is capable of drawing flow, or if the vacuum is not sustained for a least 1 minute, all fittings and tubing will be checked for tightness (or replaced), and the vacuum test will be repeated.

- The reading from the vacuum gauge pressure will be recorded in a field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for a least 1 minute.

The vacuum test should be performed for each sampling event to test for leaks in new connections.

<u>Step 2 – Leak Test</u>

- Using either lab supplied or consumer grade helium gas, ¼-inch diameter flexible tubing connected to the helium gas source is inserted from the outside of the surface shroud through a sealed penetration allowing the injection of helium gas within the void of the surface shroud. Pressurization of the shroud should be avoided so helium is not forced into the annulus of the borehole. The personal sampling pump should be used to draw a sample of air from beneath the shroud into a Tedlar® bag. The Tedlar® bag sample is then connected to a pre-calibrated hand-held helium detector (Dielectric MGD-2002, Mark Model 9522, or equivalent) to determine the source concentration of helium beneath the shroud. An alternative to collecting a sample of air from inside the shroud with a Tedlar Bag would be to insert the helium detector directly into or below the shroud.

- Once the tubing is situated and sealed at the penetrations, the surface shroud must have an air tight seal against the SVP surface pad or flush mount opening. As noted with the surface shroud itself, the sealing agent can be anything that maintains an airtight seal and does not introduce contamination or other adverse effects to the SVP or sample quality (e.g., modeling clay).

- Once a stable helium concentration is maintained beneath the shroud, the personal sampling pump can be connected to the SVP sample tubing and used to purge the appropriate volume of air out of the SVP in accordance with the purge calculation illustrated in *FMG 3.10 – Installation Procedure for Soil Vapor Monitoring Points.* A sample of the purged air should be collected in a Tedlar® bag near the end of the purging. The Tedlar® bag sample is then connected to the hand-held helium detector to test for the presence of helium in the purged air. The surface seal is verified if helium is either:

    - Not detected in the purged air; or

    - Detected in the purged air at a concentration not greater than 10 percent of the helium source concentration beneath the shroud.

While maintaining the stable helium concentration, the portable purge pump is disconnected and the sample collection apparatus is connected to the SVP dedicated sample tubing. The sample collection apparatus typically consists of 6-liter, 1-liter or smaller SUMMA®-Type canisters equipped with low volume (100-200 ml/min) flow controllers. SUMMA®-Type canisters are commonly utilized for soil vapor sampling when it is necessary to achieve low DLs. The preference is for smaller volume samples (and, thus smaller canisters) unless larger canisters are specified by applicable guidance or the project specific Sampling and Analysis Plan. The sample collection apparatus can also consist of Tedlar® bags that are filled using a vacuum box. The use of Tedlar® bags is appropriate when achieving low DLs or reliable quantitation to support risk assessment is not necessary. Sample collection procedures using both SUMMA®-Type canisters and Tedlar® bags are discussed in detail below.

(Note: If the leak test fails, the SVP should be evaluated and repaired, and/or abandoned and re-installed.)

The leak test should be performed during the first sampling event for a newly installed soil gas port. If the leak test fails, the SVP should be evaluated and repaired, and/or abandoned and re-installed. Once a successful leak test has been administered, subsequent helium leak tests are not necessary as long as the integrity of the soil gas port is not in question and the lead regulatory agency has confirmed that this approach is acceptable to them.

SAMPLE COLLECTION

Soil gas sampling should not be performed during or within 48 hours of a significant rainfall event. Soil vapor samples are collected using either certified SUMMA®-Type Canisters with dedicated time integrated flow controllers, or Tedlar® bags in conjunction with a vacuum box. The applicable regulatory guidance and project specific Sampling and Analysis Plan will dictate whether SUMMA® canisters or Tedlar® bags are appropriate for sample collection. For SUMMA® canisters, the size of the canister and the flow rate requirements will be specified in the project specific Sampling and Analysis Plan. The details of sample collection immediately following the purging and leak testing described above using either SUMMA® canisters or Tedlar® bags are presented below.

SUMMA® Canisters

Prior to connecting the SUMMA® canister to the dedicated sample tubing for any SVP, the identification number from both the SUMMA® canister and flow controller and the initial vacuum reading must be recorded in the field book, on the sampling log, and analytical Chain of Custody (COC). If the initial vacuum is less than -25 inches of mercury (e.g., -20 in. Hg), the canister should not be used for sample collection.

During the installation of the SVP, the dedicated sampling tubing (stainless steel, teflon, Nylaflow® or similar) should be equipped with the appropriate stainless steel or brass Swagelok® fittings and ferrules necessary to connect to the specified flow controller/SUMMA® canister. Connect the SVP tubing to the flow controllers using Swagelok compression fittings so that the ferrule seals to the tubing. Turn the SUMMA® canister valve to the "open" position, and immediately record the SUMMA® canister serial number and the sample start time in a field book or on a sampling log form, and on the Chain of Custody form. For field duplicate sample collection, the procedure described above is followed except for the addition of another flow controller/SUMMA® canister connected to a "T" apparatus designed specifically for duplicate sampling that is provided by the analytical laboratory.

Termination of sample collection is achieved by turning the SUMMA® canister valve to the "close" position. The sample time and vacuum gauge on the flow controller must be monitored to insure that the vacuum is not completely released. In high permeability soils, the canister should fill sufficiently within the designated sampling period (period set by the flow controller). In low permeability soils, it may be necessary to allow the canister to collect the sample for a longer period of time to insure a sufficient volume is collected. The final vacuum should be 5 in. Hg or less, but greater than zero; 2 in. Hg is a sufficient target vacuum to reach before termination of sample collection. If the SUMMA® canister is allowed to equilibrate to atmospheric pressure (i.e., the vacuum is completely released) sample quality may be compromised. In the event that the vacuum gauge on the flow controller is not accurate (damaged in shipping, etc.), field personnel will need to use their best judgment on when to terminate the sample based on knowledge of soil type, the sample duration, and the vacuum gauge. Excessive vacuum remaining in a canister may result in elevated reporting limits.

Immediately following sampling, the SUMMA® canister should be disconnected from the sampling tubing. The personal sampling pump should then be connected to sampling tubing and used to draw an air sample into a Tedlar® bag. The helium concentration within the Tedlar® bag air sample should be measured using the pre-calibrated hand-held helium detector. The surface seal is verified if helium is either:

- Not detected in the purged air; or
- Detected in the purged air at a concentration not greater than 10 percent of the helium source concentration beneath the shroud.

Although a flow regulator has a given flow rate and time associated with sampling, sample times are dependent on soil properties. Cohesive soils (silts and clays) with relatively less interconnected air voids within the soil matrix will not allow the vacuum to pull the soil vapor as readily as a granular soil type (clean sand and gravel). Further, soil moisture can affect the sample time as well. The sampler should monitor the sample tubing and apparatus during collection, to ensure that water incursion (from soil moisture) does not occur. Should water incursion occur the sample integrity is compromised and may result in the permanent fouling of the SUMMA® canister. A wide range of sample times should be expected. Ensuring that the final vacuum is between 2 and 5 in. Hg is more important than the amount of time it takes to collect the sample unless simultaneous sampling is a requirement of the Sampling and Analysis Plan. In certain situations, such as extremely tight soils, if an appropriate 1-liter sample cannot be obtained within 60 minutes, the location may be described as not yielding soil vapor and sampling should be abandoned.

<u>Tedlar® Bags and Vacuum Box</u>

During the installation of the SVP, the dedicated sampling tubing (stainless steel, teflon, Nylaflow® or similar) should be equipped with the appropriate stainless steel or brass Swagelok® fittings and ferrules necessary to connect to the sampling port of the vacuum box. Connect the SVP sampling tubing to the sampling port of the vacuum box so that the ferrule seals to the tubing. Connect a fresh unused Tedlar® bag to the sampling port on the inside of the vacuum box, and then seal the vacuum box. Connect the personal sampling pump to the evacuation port of the vacuum box. Immediately record the Tedlar® bag serial number and the sample start time in a field book or on a sampling log form, and on the Chain of Custody form. Open the valves on the vacuum box to both the sampling and evacuation ports. Turn on the personal sampling pump to evacuate the air sealed inside vacuum box to create a vacuum inside the box. The vacuum causes the Tedlar® bag to expand, which draws a soil vapor from the SVP into the bag. Sample collection is complete when the bag is filled to 80% of its volume. Care should be taken not to over-fill the bag or it will rupture. When the bag approaches being 80% full, the vacuum within the box can be reduced by closing down the valve on the evacuation port. Once the bag is filled to 80% of its volume, the valves to the sampling and evacuation ports can be closed, pump turned off, and the vacuum box can be opened. The valve to the Tedlar® bag can be closed, and the bag can be disconnected from the sampling port on the vacuum box. The Tedlar® bag should be 'conditioned' by filling it and emptying it three times prior to a final filling to obtain the sample to be analyzed by the lab. The conditioning step will help ensure that any surface active areas within the bag are well exposed to the soil vapor sample and do not adsorb significant VOCs that could bias the final sample. Analysis of the Tedlar® bag sample should be arranged to occur with 36 hours of sample collection to avoid potential VOC losses during storage. For field duplicate sample collection, the procedure described above is followed except for the addition of a second vacuum box/Tedlar® bag connected to a "T" apparatus designed specifically for duplicate sampling that is provided by the analytical laboratory.

Immediately following sampling, the vacuum box should be disconnected from the sampling tubing. The personal sampling pump should then be connected to sampling tubing and used to draw an air sample into a Tedlar® bag. The helium concentration within the Tedlar® bag air sample should be measured using the pre-calibrated hand-held helium detector. The surface seal is verified if helium not detected or detected in the sample at a concentration not greater than 10 percent of the helium source concentration beneath the shroud. The absence of helium, or presence of helium no greater than 10 percent of the helium source concentration beneath the shroud, in the air sample verifies that the integrity of the surface seal was maintained during sample collection.

WASTE MANAGEMENT

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves, disposable clothing, and other disposable equipment will be disposed of in accordance with *FMG-10.0 – Waste Characterization.*

REFERENCES

1. United States Environmental Protection Agency (USEPA), Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), OSWER-530-D-02-0004, November 2002.

2. Indiana Department of Environmental Management (IDEM), Draft Vapor Intrusion Pilot Program Guidance, April 26, 2006.

3. American Petroleum Institute (API), Collecting and Interpreting Soil Gas Samples from the Vadose Zone: A Practical Strategy for Assessing the Subsurface-Vapor-to-Indoor Air Migration Pathway at Petroleum Hydrocarbon Sites. American Petroleum Institute, Publication Number 4741, November 2005.

4. California Environmental Protection Agency, Advisory – Active Soil Gas Investigations. Department of Toxic Substances Control and California Regional Water Quality Control Board, Los Angeles Region. January 28, 2003.

5. New York State Department of Health (NYSDOH), Guidance for Evaluating Soil Vapor Intrusion in the State of New York, , Center for Environmental Health, Bureau of Environmental Exposure Investigation. October 2006.

Air/Vapor Sampling Form

Client: ____________________

Location: ____________________

Project No.: ____________________

Sample ID	Location	Start Date	Lab	Canister					Flow Controller			Purging		Tedlar Bag		Leak/Tracer Test		Start Time	End Time
				No.	Size	Type	Pressure (in Hg)		No.	Type	Flow Rate (±5%)	Purge Rate	Purge Volume	Size	Fill Rate	Initial Reading	End Reading		
							Intial	Final											

Climate

Date	Time	Temp. (°F)		Humidity	Wind (mph)	Press. (in.)	Precip. (in.)
		Indoor	Outdoor				

Notes

APPENDIX B

SPDES PERMIT STORM WATER MONITORING REQUIREMENTS

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS
During the period beginning EDM (August 1, 2001)
and lasting until March 1, 2004 the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations Daily Avg.	Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Sample Type
002 - Storm Runoff					
Flow	NA	Monitor	MGD	Quarterly	Instantaneous
Aluminum, Total	NA	Monitor	mg/l	Quarterly	Grab
Iron, Total	NA	Monitor	mg/l	Quarterly	Grab
Oil & Grease	NA	Monitor	mg/l	Quarterly	Grab
Zinc, Total	NA	Monitor	mg/l	Quarterly	Grab
Solids, Total Suspended	NA	Monitor	mg/l	Quarterly	Grab
Tetrachloroethylene	NA	Monitor	mg/l	Quarterly	Grab
Trans-1,2-Dichloroethylene	NA	Monitor	mg/l	Quarterly	Grab
Trichloroethylene	NA	Monitor	mg/l	Quarterly	Grab
003 - Storm Runoff					
Flow	NA	Monitor	MGD	Quarterly	Instantaneous
Iron, Total	NA	Monitor	mg/l	Quarterly	Grab
Lead, Total	NA	Monitor	mg/l	Quarterly	Grab
Oil & Grease, Total	NA	Monitor	mg/l	Quarterly	Grab
Zinc, Total	NA	Monitor	mg/l	Quarterly	Grab
Solids, Total Suspended	NA	Monitor	mg/l	Quarterly	Grab
Tetrachloroethylene	NA	Monitor	mg/l	Quarterly	Grab
Trans-1,2-Dichloroethylene	NA	Monitor	mg/l	Quarterly	Grab

Note: Grab sample for the purposes of outfalls 002 and 003 shall mean a single sample taken over a period not exceeding 15 minutes.

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning EDPM (01/01/94)

and lasting until March 1, 1994

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations (4) Daily Avg.	Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Sample Type
002 & 003 - Storm Water					
Flow	Monitor	Monitor	MGD	Quarterly	#
pH (Range)	Monitor	Monitor	SU	Quarterly	#
Temperature,	Monitor	Monitor	°C	Quarterly	#
Ammonia, Total, as N	Monitor	Monitor	mg/l	Quarterly	#
BOD_5	Monitor	Monitor	mg/l	Quarterly	#
COD	Monitor	Monitor	mg/l	Quarterly	#
Cyanide, Amenable to Chlorination	Monitor	Monitor	mg/l	Quarterly	#
Fluoride	Monitor	Monitor	mg/l	Quarterly	#
Oil and Grease	Monitor	Monitor	mg/l	Quarterly	#
Phenols, Total	Monitor	Monitor	mg/l	Quarterly	#
Total Suspended Solids	Monitor	Monitor	mg/l	Quarterly	#
Aluminum, Total	Monitor	Monitor	mg/l	Quarterly	#
Antimony, Total	Monitor	Monitor	mg/l	Quarterly	#
Arsenic, Total	Monitor	Monitor	mg/l	Quarterly	#
Beryllium, Total	Monitor	Monitor	mg/l	Quarterly	#
Cadmium, Total	Monitor	Monitor	mg/l	Quarterly	#
Chromium, Hexavalent	Monitor	Monitor	mg/l	Quarterly	#
Chromium, Total	Monitor	Monitor	mg/l	Quarterly	#
Copper, Total	Monitor	Monitor	mg/l	Quarterly	#
Iron, Total	Monitor	Monitor	mg/l	Quarterly	#
Lead, Total	Monitor	Monitor	mg/l	Quarterly	#
Manganese, Total	Monitor	Monitor	mg/l	Quarterly	#
Nickel, Total	Monitor	Monitor	mg/l	Quarterly	#
Selenium, Total	Monitor	Monitor	mg/l	Quarterly	#
Silver, Total	Monitor	Monitor	mg/l	Quarterly	#
Thallium, Total	Monitor	Monitor	mg/l	Quarterly	#
Zinc, Total	Monitor	Monitor	mg/l	Quarterly	#
Tetrachloroethylene	Monitor	Monitor	mg/l	Quarterly	#
1,2-trans-Dichloroethylene	Monitor	Monitor	mg/l	Quarterly	#
Trichloroethylene	Monitor	Monitor	mg/l	Quarterly	#
Total Toxic Organics(3)	Monitor	Monitor	mg/l	Quarterly	#

Footnotes:

(3) & (4) - See page 6 of 9.

One grab sample shall be taken in the first 60 minutes of discharge and then one additional grab sample for each additional hour of discharge. For discharges lasting four or more hours, a minimum of four grab samples shall be collected. Samples are to be analyzed separately and reported as a flow weighted average.

91-20-2a (1/89)

SPDES No.: NY 000 0558

FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS MODIFICATION DATE: 9/16/93

During the period beginning EDPM (09/16/93)

and lasting until March 1, 1994

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations [8] Daily Avg.	Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Sample Type
002 & 003 - Storm Water:					
Flow	Monitor	Monitor	MGD	Quarterly	Instantaneous#
pH (Range)	Monitor	Monitor	SU	Quarterly	Instantaneous#
Temperature,	Monitor	Monitor	°F	Quarterly	Instantaneous#
Ammonia, Total, as N	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
BOD_5	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
COD	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Cyanide, Amenable	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Fluoride	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Oil and Grease	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Phenols, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Total Suspended Solids	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Aluminum, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Antimony, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Arsenic, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Beryllium, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Cadmium, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Chromium, Hexavalent	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Chromium, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Copper, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Iron, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Lead, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Manganese, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Nickel, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Selenium, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Silver, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Thallium, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Zinc, Total	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Tetrachloroethylene	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
1,2-trans-Dichloroethylene	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Trichloroethylene	Monitor	Monitor	mg/l	Quarterly	Instantaneous#
Total Toxic Organics	Monitor	Monitor	mg/l	Quarterly	Instantaneous[7]

Footnotes:

(7) & (8): See footnotes 7 and 8 on page 6 of 9.

One grab sample shall be taken in the first 60 minutes of discharge up to a maximum of four grab samples for discharges lasting four or more hours. Samples are to be analyzed separately and reported as a flow weighted average.

JC:I

91-20-2a (7/84)

OBSSOLETE - REFERENCE ONLY

Facility ID # NY 0000558

_ Final

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the Period Beginning EDP (March 1, 1989)

and lasting until EDP + 5 Years (March 1, 1994)

the discharges from the permitted facility shall be limited and monitored by the permittee as specified below:

Outfall Number & Effluent Parameter	Discharge Limitations (8) Daily Avg.	Daily Max.	Units	Minimum Monitoring Requirements Measurement Frequency	Sample Type
002 & 003 Storm Water					
Flow - MGD	Monitor	Monitor		Monthly	Instantaneous#
pH (min - max.)	"	"		"	"
Temperature-deg °C(°F)	"	"		"	"
Ammonia, Total, as N - mg/l	"	"		"	"
BOD5 - mg/l	"	"		"	"
COD - mg/l	"	"		"	"
Cyanide, Amenable to Chlorination - mg/l	"	"		"	"
Fluoride - mg/l	"	"		"	"
Oil and Grease - mg/l	"	"		"	"
Phenols, Total - mg/l	"	"		"	"
Total Suspended Solids - mg/l	"	"		"	"
Aluminum, Total - mg/l	"	"		"	"
Antimony, Total - mg/l	"	"		"	"
Arsenic, Total - mg/l	"	"		"	"
Beryllium, Total - mg/l	"	"		"	"
Cadmium, Total - mg/l	"	"		"	"
Chromium, Hexavalent - mg/l	"	"		"	"
Chromium, Total - mg/l	"	"		"	"
Copper, Total - mg/l	"	"		"	"
Iron, Total - mg/l	"	"		"	"
Lead, Total - mg/l	"	"		"	"
Manganese, Total - mg/l	"	"		"	"
Nickel, Total - mg/l	"	"		"	"
Selenium, Total - mg/l	"	"		"	"
Silver, Total - mg/l	"	"		"	"
Thallium, Total - mg/l	"	"		"	"
Zinc, Total - mg/l	"	"		"	"
Tetrachloroethylene - mg/l	"	"		"	"
1,2-trans Dichloroethylene - mg/l	"	"		"	"
Trichloroethylene - mg/l	"	"		"	"
Total Toxic Organics - mg/l	"	"		"	" (7)

Footnotes:

(7) (8) - See Page 6 of 9

\# One grab sample shall be taken in the first 60 minutes of discharge up to a minimum of four grab samples for discharges lasting four or more hours. Samples are to be analyzed separately and reported as a flow weighted average.