July 20, 2017

U.S. EPA Region 5
Remediation and Reuse Branch
Land and Chemicals Division, LU-9J
77 West Jackson Blvd.
Chicago, IL 60604-3590
Attn: Mirtha Cápiro

RE: Primary Groundwater Source Area Interim Measures Work Plan Addendum
RACER Trust Moraine Facilities
Moraine, Ohio

Dear Ms. Cápiro:

The Revitalizing Auto Communities Environmental Response Trust (RACER Trust) is providing this Primary Groundwater Source Area Interim Measures Work Plan Addendum (Addendum) for the RACER Trust Moraine Facilities in Moraine, Ohio. This is an Addendum to the June 1999 Primary Groundwater Source Area (AOI 7) Interim Measures Work Plan that was approved by the United States Environmental Protection Agency (U.S. EPA) in July 1999. This Addendum was prepared following the December 31, 2012 Corrective Measures Proposal and the October 21, 2016 Proposed Final Remedy Components Amendment that detailed the remedial benefits of a modified enhanced reductive dechlorination (ERD) in-situ reactive zone approach to target areas of the Site containing residual source mass as part of an integrated plume-wide remedial strategy. This approach was further discussed in a meeting between RACER Trust, Arcadis U.S., Inc. (Arcadis), the U.S. EPA, and the Ohio Environmental Protection Agency (Ohio EPA) on January 24 and 25, 2017 and again on April 18 and 19, 2017.

The Addendum summarizes ERD pilot test activities planned for the former Process Sump Area (PSA), pilot test objectives, planning activities, well installation activities, hydraulic testing methodologies, injection testing methodologies, investigation derived waste management activities, planned reporting, and project schedule. Per the U.S. EPA's request, sub-slab and indoor air sampling will be completed in the former PSA approximately 3 months after injection testing is completed or sooner if the performance monitoring data indicates excessive dissolved gas generation, which is not anticipated. The sub-slab and indoor air sampling will be completed in accordance with the approved March 4, 2011 Sub-Slab and Indoor Air Sampling Work Plan, August 12, 2016

Sub-Slab and Indoor Air Sampling Work Plan Addendum No. 3, and September 12, 2016 Sub-Slab and Indoor Air Sampling Work Plan Addendum No. 6.

If you have any questions, please contact me at (937) 751-8635.

Sincerely,

Pamela L. Barnett, PG
Cleanup Manager (DE, LA, MA, OH, PA, VA)
RACER Trust

cc: Valerie Orr – Ohio EPA

Revitalizing Auto Communities Environmental Response Trust (RACER Trust)

PRIMARY GROUNDWATER SOURCE AREA INTERIM MEASURES WORK PLAN ADDENDUM

Former Delphi Harrison Thermal Systems, Moraine Plant
Former General Motors Powertrain Group, Moraine Engine Plant
Former General Motors Truck Group, Moraine Assembly Plant
Moraine, Ohio

July 2017

CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION AND OBJECTIVES

This Primary Groundwater Source Area Interim Measures Work Plan Addendum (Addendum) has been developed to describe the design basis and methodology for implementation of the enhanced reductive dechlorination (ERD) pilot test in the former Process Sump Area (PSA) at the Revitalizing Auto Communities Environmental Response Trust (RACER Trust) (formerly General Motors Corporation [former GM Corporation]) facilities located in Moraine, Ohio (Site). This is an addendum to the Primary Groundwater Source Area (AOI 7) Interim Measures Work Plan (Arcadis Geraghty & Miller, Inc., 1999) that was approved by the United States Environmental Protection Agency (U.S. EPA) in July 1999. The Site includes the former Delphi Harrison Thermal Systems Moraine Plant (former Delphi Thermal Moraine), former General Motors Powertrain Group, Moraine Engine Plant (former Moraine Engine), and former General Motors Truck Group, Moraine Assembly Plant (former Moraine Assembly) (Figure 1).

This Addendum was prepared following the 2012 Corrective Measures Proposal (2012 CMP; Arcadis, Inc. 2012a) and the Proposed Final Remedy Components Amendment (Amendment; RACER Trust, 2016a) that detailed the remedial benefits of a modified ERD in-situ reactive zone (IRZ) approach to target areas of the Site containing residual source mass as part of an integrated plume-wide remedial strategy. This approach was further discussed in a meeting between RACER Trust, Arcadis U.S., Inc. (Arcadis), the U.S. EPA, and the Ohio Environmental Protection Agency (Ohio EPA) on January 24 and 25, 2017.

The treatment objective of the modified ERD approach is source area treatment to achieve a reduction of site-specific volatile organic compound (VOC) concentrations in the former PSA by one order of magnitude in areas where site-specific VOC concentrations are in excess of 1 part per million (ppm) and by two orders of magnitude in areas where site-specific VOC concentrations are greater than 5 ppm. While the one or two order of magnitude source reduction is the overarching objective of the source zone remedy, the intent of the source treatment program is to limit or eliminate the transport of VOCs to the dilute downgradient groundwater plume which may be achievable with localized areas of VOCs present in the source areas above the order of magnitude reduction targets. Operation of the full-scale remedial approach would therefore be completed to address accessible source mass within the limits of technical practicability while achieving the necessary reduction in VOC source discharge to enable treatment of the dilute plume to the Maximum Contaminant Level (MCL) targets at the Site property boundary.

The ERD pilot test objectives are:

- To verify and evaluate upper aquifer geologic conditions and to obtain data to support the full-scale injection well design (e.g., target screen interval depths and well construction)
- To perform hydraulic, injection, and tracer testing to evaluate and confirm formation injectability, injection well spacing (horizontal and vertical), and injection reagent dosing
- To complete performance monitoring to evaluate the expected distribution and longevity of organic carbon substrate and transport during expanded source treatment

A detailed description of the pilot test elements to achieve the ERD pilot test objectives listed above is included in the subsequent sections of this Addendum.

1.1 ERD Overview

ERD is a remedial technology that relies on the metabolic processes of subsurface microorganisms to degrade groundwater constituents. Specifically, during ERD of VOCs, the chlorinated compound (e.g., trichloroethene [TCE]) can be utilized as the electron acceptor for microbial respiration. For this to occur, an electron donor (e.g., hydrogen generated from fermentation of a carbon source) must be present in sufficient quantities. This process occurs intrinsically in the presence of naturally-occurring carbon sources that are capable of serving as electron donors; however, this process can be enhanced by injecting a carbon substrate (e.g., emulsified vegetable oil [EVO]) into the subsurface to create a biological in-situ reactive zone. Organic carbon injections are conducted to achieve four basic goals:

1. Overcome the continuous electron acceptor supply: This includes oxygen, nitrate, and other electron acceptors that tend to support a more aerobic microbial community.
2. Produce molecular hydrogen through fermentation: Molecular hydrogen is a product of fermentation and is used as an electron donor by dechlorinating bacteria.
3. Achieve complete dechlorination of the target compounds: Dechlorinating bacteria use the hydrogen produced through fermentation as an electron donor and VOCs as electron acceptors. Hydrogen atoms are substituted for chlorine atoms in the dehalorespiration process resulting in a sequential chemical reduction of VOC molecules, which for tetrachloroethene (PCE) follows the pathway:

PCE → TCE → cis-1,2-dichoroethene → vinyl chloride → ethene

Note: The primary parent products present within then former PSA are both PCE and TCE.

4. Achieve dissolution of sorbed-phase VOC mass: ERD enhances the dissolution rate of VOC mass, making it available for treatment in the dissolved phase and thus shortening the remedial timeframe.

The characteristics and extent of an established reactive zone are generally determined by the effectiveness of carbon substrate delivery over the targeted treatment area. By maintaining an in-situ total organic carbon (TOC) concentration greater than background within the reactive zone, the microbial ecology will adapt, encouraging proliferation of bacteria that participate directly in VOC reduction to the innocuous end products ethene and eventually ethane.

Based on the conceptual site model (CSM) for the former PSA and previous bioremediation success at the Site, the ERD technology was selected for an evaluation of on-site groundwater remediation during this pilot test.

1.2 Site Description and History

The Site has been used for industrial purposes since the property was acquired in the mid-1920s by former GM Corporation. The historical Site operations have included appliance manufacturing, machining and assembly of automotive air conditioning equipment, automotive machining and painting, and the assembly of diesel engines. The former Moraine Engine and Moraine Assembly facilities occupy approximately 282 acres, while the adjacent former Delphi Thermal Moraine facility occupies approximately 143 acres. Most of the historical structures have been demolished; however, some structures remain on-site (Figure 1). The ground cover is largely comprised of concrete building foundation floors, intact and deteriorated concrete and asphalt pavement, and gravel and open soil surfaces with plant growth.

On June 30, 2011, RACER Trust sold the properties, former Delphi Thermal Moraine, former Moraine Engine Plant, and former Moraine Assembly Plant to Industrial Realty Group Moraine, LLC (IRG). As part of the property transfer, RACER Trust retained environmental liability for these properties. The closed South Settling Lagoon was not included in this property transaction and is retained by RACER Properties LLC. IRG currently leases several portions of the Site for industrial purposes. IRG sold several portions of the property to Copart of Connecticut, Inc., Fuyao Asset Management A, LLC, and Inland Property Management, Inc. in 2014. Current Site operations include multi-tenant use for industrial purposes.

Additional details regarding former Site operations and remedial actions are provided in the 2012 CMP (Arcadis, Inc. 2012a), the Updated Former Process Sump Area Draft Data Package (RACER Trust, 2016b), and the Site-Wide Groundwater Monitoring Report for 2016 (Arcadis, Inc. 2017).

1.3 Area-Specific Conceptual Site Model

This CSM is focused on area-specific information as it relates to the upper aquifer in the former PSA. Information presented was gathered from the 2012 CMP (Arcadis, Inc. 2012a), Updated Former Process Sump Area Draft Data Package (RACER Trust, 2016b), and from recent concentration data presented in the Site-wide Groundwater Monitoring Report for 2016 (Arcadis, Inc. 2017), and these documents should be referred to for additional detail regarding the CSM. This section discusses area-specific upper aquifer geology/hydrogeology, hydraulic characteristics, and plume distribution.

1.3.1 Area-Specific Geology / Hydrogeology

The Site is situated within a glacial, buried valley, which is underlain by glacial outwash sand and gravel deposits, along with interspersed to semi-continuous glacial till. The Site is distinguished by three primary hydrostratigraphic units, including two principal aquifers (upper aquifer and lower aquifer) and a mostly continuous clay-rich till (regional clay till) that divides these two aquifers. Within the former PSA area, a discontinuous upper clay till layer separating the upper aquifer has also been encountered. The upper aquifer saturated thickness in the former PSA ranges from approximately 35 to 40 feet with areas dominated by fine grained deposits (clay, silt, fine sand) that account for 50 percent (%) or more of the deposits. Boring and well construction logs that are representative of the area are included in Appendix A.

Bedrock, consisting of Ordovician shales and limestones of the Richmond Group, comprise the dominant bedrock units forming the valleys. Elevations of bedrock are lowest near the Great Miami River, southwest of the Site, at approximately 500 feet above mean sea level (AMSL). The bedrock valley wall is encountered just to the west/northwest of the Site, west of the Great Miami River. The bedrock valley wall to the east starts rising approximately 6,000 feet east of the Site in Kettering. A local bedrock high is present just south of the former Oil House Area, and extends east to the former PSA. The location of the localized bedrock high feature correlates to the increased interbedded nature of the unconsolidated deposits of the upper aquifer in the former Oil House Area and former PSA.

1.3.2 Upper Aquifer Hydraulic Characteristics

Regionally, the upper aquifer consists of two distinguishable facies, a highly permeable facie (i.e., sand and gravel) and a less permeable facie (i.e., interbedded fine sand, silt, clay, and till). The former PSA contains materials consistent with both of these facies, where less permeable soils being dominated by chemical diffusion mechanisms and channelized sand and gravel zones are dominated by rapid advective groundwater transport. Groundwater generally flows from the northeast to the southwest with a horizontal hydraulic gradient of 3.0×10^{-4} feet per foot (ft/ft) using groundwater elevation data from upper aquifer wells GM-75S and GM-68S in 2016.

Hydraulic testing results from the Pre-Design Investigation (Arcadis, Inc. 2012b) discreet point testing from vertical aquifer profiling intervals indicates a range of hydraulic conductivity that spans three orders of magnitude that is consistent with the high degree of heterogeneity of the hydrostratigraphic units.

1.3.3 Area-Specific Plume Concentrations and Distribution

Total site-specific VOC results in the upper aquifer from 2016 are shown on Figure 2. Site-specific VOC concentrations exceeding 60,000 micrograms per liter (ug/L) have been observed in the southwest corner of the former Moraine Assembly Plant building and former PSA. Concentrations exceeding 1,000 ug/L are distributed to the southwest of the former PSA and decrease cross-gradient and downgradient with an estimated total plume width of 600 feet. The target treatment area (see Figure 2) extends to the top of the regional clay till (i.e., approximately 65 ft bgs). The most elevated site-specific VOC concentrations were observed in the fine sands and silty sands that are interbedded with clay.

1.4 Proposed Final Remedy Components

Through a series of communications, the U.S. EPA has requested that additional remedial components be incorporated into the final remedy for the Site to further reduce concentrations of diffuse plume contaminants and expedite the remedial timeframe. The Amendment (RACER Trust, 2016a) included an update to the proposed final remedy components for the Site that were summarized in the 2012 CMP (Arcadis Inc. 2012a). The Amendment recommended modifying the source area treatment footprint within the former PSA in the upper aquifer as a component of the final remedy. The current proposed treatment footprint is provided on Figure 2.

The Amendment summarized the final remedy components included in the 2012 CMP (Arcadis Inc. 2012a) and detailed the recommended modifications to the 2012 CMP final remedy components. Specifically, three final remedy modifications were recommended:

1. Dynamic Groundwater Recirculation™ would be included as a component of the final remedy to address the diffuse groundwater plume in the upper aquifer on-site and off-site in the Riverview Plat neighborhood.
2. Minor modifications to the source area treatment footprint within the former PSA should be made based on delineation activities completed after submittal of the 2012 CMP (Arcadis, Inc. 2012a).
3. If necessary, on-site vapor intrusion mitigation at the existing buildings will be incorporated into the remedy.

In response to comments from the U.S. EPA during a November 7, 2016 phone conversation, the Proposed Final Remedy Components – Cost Estimate Supporting Documentation (RACER Trust, 2016c) and the Proposed Final Remedy Components Amendment – Response to U.S. EPA (RACER Trust, 2016d) were submitted to the U.S. EPA and provided additional details regarding the proposed final remedy. The objectives of the ERD pilot test align with supporting the proposed final remedy components as they relate to source area treatment.

2 PLANNING ACTIVITIES

The field tasks associated with this Addendum will be completed in accordance with the Standard Operating Procedures (SOPs) presented in Appendix B and field forms presented in Appendix C. Field work will be completed following the procedures identified in the Site-Specific Health and Safety Plan (HASP; Arcadis, Inc. 2016). The HASP includes a description of the safety risks associated with the tasks detailed in this Addendum. A clear process for mitigating these risks is communicated in the HASP. It is also to be noted that safe, functional access to the Site is available to complete the ERD pilot test activities.

2.1 Permitting

Based on the activities associated with this ERD pilot test, the only required permit is an underground injection control (UIC) permit. The request for the UIC permit will be prepared and submitted following the Ohio EPA, UIC Program reviews of this Addendum. The UIC permit request will include a summary of the injection activities, reagent (i.e., organic carbon substrate and tracer) dosing rates, total volume of injection solution, performance monitoring program, and anticipated duration of the pilot test.

2.2 Utility Clearance

Prior to any invasive activities, underground utilities will be cleared and locations will be surveyed for overhead utilities. Utilities will be cleared following the Arcadis Utility Location Policy and Procedures. A copy of the Arcadis Utility Location Policy and Procedures can be found in the HASP (Arcadis, Inc. 2016). At a minimum, Arcadis will contact the Ohio Utility Protection Service, review available facility utility drawings, and conduct a detailed visual site inspection. Invasive utility clearance procedures will be completed, which may include clearing each boring using an “air-knife” or similar device to an approximate depth of approximately 6 feet below ground surface (ft bgs). Other lines of evidence which may be utilized include, but are not limited to, a private utility locating service, hand augering or digging, and utility provided utility location maps.

3 PILOT TEST METHODOLOGY

As discussed in Section 1, the primary objective of this pilot test is to obtain and verify the remedial design parameters for the design and implementation of a full-scale ERD remedy to treat residual source mass in the upper aquifer at the former PSA. Information related to the following full-scale design considerations that are to be obtained or supported by this pilot test include:

- Upper aquifer permeability and the necessary target treatment thickness in the former PSA area
- The volume to radial fluid distribution relationship within former PSA soils
- The vertical and horizontal placement of injection and monitoring well(s) to achieve treatment objectives
- Information related to reagent dosage and injection frequency, notably the extent of subsurface dilution, consumption, and persistence

To obtain this information, a carbon solution and tracer dye will be injected into the subsurface. Data will be collected from monitoring wells within the pilot area to evaluate groundwater transport velocity, organic carbon longevity, and degradation of contaminants.

The pilot test will consist of introducing a dilute EVO solution, mixed with potable water, into injection wells. During and following injection, the pilot test monitoring network, comprised of newly installed and select, existing monitoring wells, will be used to monitor reagent distribution behavior within the injection footprint and further downgradient (Figure 3). The eight new monitoring wells will be installed at various distances from the injection wells to evaluate the radius of influence (ROI) of both EVO and tracer dye. Injection wells will be screened at multiple depths to cover anticipated influence of formation heterogeneities on the organic carbon substrate distribution.

Rhodamine Water Tracing (WT), a non-toxic, fluorescent dye, will be mixed with the injection solution and injected into the injection wells as a tracer to supplement the distribution, transport, and longevity monitoring of the EVO carbon source. Rhodamine WT is used frequently in environmental applications (Holmbeck-Pelham et al., 2000; Aley, 2002; Field, 2005; Nelson and Divine, 2005).

The performance monitoring program will consist of three phases: 1) baseline monitoring to establish pre-test conditions (e.g., contaminant concentrations and geochemical environment); 2) injection monitoring of EVO and tracer dye to determine the formation mobile fraction and achievable injection flow rates and pressures; and 3) post-injection monitoring to verify distribution, transport, and longevity of the EVO and tracer dye.

An adaptive design concept will be used throughout the process to optimize remedial performance. For example, the well locations and screen intervals will be based on the heterogeneity of the formation and may be adjusted based on field drilling observations. Further, the injection inputs (e.g., flow rates and pressures) and monitoring program decisions (e.g., sampling frequency and analytes) will be adjusted, as needed, based on injection progress and monitoring results.

4 WELL DESIGN, INSTALLATION, AND HYDRAULIC TESTING

The new wells to be installed for the ERD pilot test will be used to refine the understanding of injection well spacing and target vertical screen intervals for optimized delivery during full-scale remedy implementation. Drilling observations collected during well installation will be used in conjunction with other vertical profiling information from the former PSA to determine the final screened interval for the pilot injection wells. Additional aquifer characterization data will be collected during well installation, including stratigraphic logging, soil characterization (e.g., grain size analysis and soil organic carbon fraction analysis), and hydraulic testing during both well development and baseline sampling activities.

4.1 Well Network and Well Design

The ERD pilot test will be implemented outside of the former Moraine Assembly Plant building between the southwestern end of the building and Springboro Pike (Figure 3). This area was selected based on the previous investigations in the former PSA and its relative proximity to identified former PSA source mass. The former PSA characterization data were used to identify the targeted depth intervals and position of the injection wells. Accessibility was also considered for selecting pilot test locations. As shown on Figure 3, the pilot test area is outside of the building, is accessible for drilling, and is not expected to limit current operations for the property and building. The locations of the wells may be modified based on unforeseen accessibility limitations and subsurface utilities.

4.1.1 Injection and Monitoring Well Design

As discussed in the CSM in Section 1.2, the geologic conditions beneath the former PSA in the upper aquifer exhibit interbedded sequences of lower permeability (i.e., contaminant mass storage) and higher permeability (i.e., contaminant transport). Therefore, the injection wells will be constructed as dual wells with screens installed at different depths to intercept the primary zones that represent storage and transport and to understand the formation heterogeneities with respect to reagent transport and distribution.

The injection well screen intervals are designed to target multiple upper aquifer intervals that contain and transport contaminants. As described above, the vertical and horizontal distribution of site-specific VOC concentrations is most pronounced in the higher permeable zones (fine sands and silty sands) that are interbedded with the low permeable features (clay). The well screen lengths and depths will be adjusted based on the known information from former PSA characterization activities (e.g., borings PSA-5 and PSA-6) and observed depths and thickness of the variable upper aquifer lithologies during drilling to support assessment of reagent injection and distribution during the pilot injection event.

As shown on Figure 4, two injection well pairs (shallow and deep portions of the upper aquifer) will be incorporated in the ERD pilot test with two design options. One design option includes two nested wells in the same borehole (i.e., PW-2S/2D, PW-3S/3D, and PW-5S/5D), and the second design option includes two paired wells installed in separate boreholes in close proximity (i.e., PW-1S/1D, PW-4S/4D, and PW-6S/6D). The alternative well installation methods are intended to evaluate the injection performance by achieving sustainable injection flow rates while monitoring the potential for short-circuiting between the upper and lower well screens through the annular space of the nested wells. This information will be used for the full-scale well design.

The injection well screen intervals will target the lower and higher permeability zones. A total of four monitoring well pairs will be installed, including three well pairs within the injection area and one well pair installed downgradient of the injection area within the former Engine Plant Building footprint west of Springboro Pike. The injection ROI is designed at 10 feet. For the purpose of verifying the assumed ROI and correlated values for mobile aquifer fraction, three dose-response well pairs (PW-4S/4D, PW-5S/5D, and PW-3S/3D) will be installed approximately 5 feet, 10 feet, and 20 feet from the injection locations (Figure 3). To evaluate potential influence of injection to the further downgradient area, one new well pair (PW-6S/6D) and two existing monitoring wells (GM-59 and GM-60) will be included as part of the monitoring program to document reagent transport (Figure 3). The assumed injection ROI was developed based on injections completed in the nearby area (e.g., the former Oil House area) and the understanding of the geologic formation in the former PSA.

As described above, the primary purpose of the pilot test is to better understand the fluid transport mechanisms in the heterogenous geology in the vicinity of the former PSA such that the full-scale injection well network can be designed to reduce VOC concentrations in both mobile (relatively more permeable) and less mobile (relatively less permeable) portions of the lithology. The primary technical objective during full-scale interim measures implementation will be to biologically reduce VOC concentrations throughout the upper aquifer in order to restrict VOC contributions to the downgradient plume (within mobile geologic intervals) and support sustained treatment of VOCs retained in less mobile storage zones. To accomplish this, the full-scale injection network will be designed to target the vertical profile of the upper aquifer where elevated VOC concentrations are present, including less permeable units. The pilot test well network identified will be used to assess the relative differences in injectability and hydraulic behavior within the variable upper aquifer geology.

4.1.2 Well Installation, Development, and Sampling

Initial borings will be advanced to the regional clay till. Soil samples will be collected, field screened for VOCs using a photoionization detector (PID), and classified based on the Udden-Wentworth grain size scale. The soil descriptions, including Unified Soil Classification System (USCS) descriptions, grain size distribution, sorting, moisture content, consistency/density, color (based on the Munsel color system), and PID readings will be recorded on field boring logs. A soil sample will be collected from the depth of the installed well screens at two of the well pairs and submitted for laboratory analyses of grain size distribution (i.e., sieve analysis) and soil organic carbon fraction. The results of grain size distribution will be used to refine the injection well construction for full-scale design. The soil organic carbon data will be used improve the understanding of residual contaminant mass in the target treatment zone.

Both nested and separate well pairs will be constructed using sonic drilling methodologies with 2-inch diameter Schedule 40 polyvinyl chloride (PVC) casing and 10-slot or 20-slot, continuous wire wrapped, stainless steel screens. The well screens will be installed at anticipated depths of 30 to 45 ft bgs and 50 to 65 ft bgs for the shallow and deep screens of each well pair, respectively. It is anticipated that the injection well filter pack will consist of Global #6 and #4/5 brand sand will be used for 10-slot and 20-slot screens, respectively. Given the highly heterogeneous and interbedded nature of the formation, the actual depth and length of screens and construction may be adjusted based on soil logging results and field VOC screening data.

Well construction will consist of the primary filter pack extending from 1 to 2 feet above the top of screen followed by 1 to 2 feet of secondary filter pack. For the nested injection well pairs, at least 2 feet of bentonite seal will be installed between the well screen intervals. Well seals will consist of neat cement to ground surface and completed with flush-mount vaults. Once installed, the wells will be developed by method of surge and volumetric purge. In addition, the ground elevation and the top-of-casing measuring point of each monitoring well will be surveyed by a licensed professional once all the wells are installed. The new monitoring wells will be installed using the same design methods as the injection wells so that these wells can serve also as injection wells during full-scale implementation, if desired. Well design specifications are detailed in Table 1 and illustrated on Figure 4.

A baseline groundwater sampling event will be completed using the low-flow sampling methodology for site-specific VOCs (Method SW-846 8260); methane, ethane, and ethene (Method AM20GAX); and TOC (Method 415.1). In addition, tracer and biogeochemical parameters, including alkalinity, nitrate, sulfate, ferrous iron (field filtered), and manganese (field filtered) will be sampled to establish baseline levels for these parameters. Field parameters including pH, specific conductance, temperature, oxidation-reduction potential, dissolved oxygen, turbidity, and depth to water will be collected as part of groundwater sampling activities.

4.2 Hydraulic Testing

Steady-state drawdown tests will be conducted at all newly installed wells during the baseline sampling event. The steady-state drawdown tests will be completed by pumping low-flow rates of less than 1,000 milliliters per minute until drawdown in the wells and measured water quality parameters stabilize. Water levels within the wells during the low-flow pumping (purging) will be monitored manually using a water level meter and recorded at five-minute intervals. Pneumatic slug testing will be completed at one select well for data verification with the steady-state drawdown testing.

5 INJECTION TEST IMPLEMENTATION

5.1 Injection System Setup

The injection system will include two injection trailers with two 500-gallon polyethylene tanks, hoses for the potable water supply, injection manifolds with flow meters/totalizers, injection wellhead assemblies for injection wells PW-1S, PW-1D, PW-2S, and PW-2D and two optional low pressure injection pumps.

Two flat-bottom tanks will be delivered to the site and installed on a flatbed trailer before the injection/tracer test begins. One of the two tanks will be used to prepare tracer solution for Rhodamine WT mixed with EVO, while the second tank will be used only for EVO solution. A secondary containment system will be placed under tanks, hoses, injection manifolds and any other equipment that contact the tracer solutions to minimize tracer solution spills.

Potable water will be obtained through a metered fire hydrant for tracer solution preparation. The Montgomery County Environmental Services department has granted access to nearby hydrants for the ongoing injections at the Site and has confirmed that nearby hydrants can be used for ERD pilot test activities.

5.2 Injection / Tracer Solution Preparation

The targeted Rhodamine WT concentration in the tracer solution will be 40 milligrams per liter (mg/L). The injection tracer solution will be mixed in 500-gallon batches with clean water from a fire hydrant and a predetermined volume of concentrated tracer stock solutions (as purchased from the vendor). One tank will be used for the EVO solution exclusively and will not encounter tracer dye solution, and the other tank will be used to mix EVO and Rhodamine WT tracer together. The volumes of concentrated tracer stock solution needed to prepare different batch volumes of 40 mg/L injection tracer solution and additional information regarding batch solution preparation are summarized in Appendix B.

The theoretical injection solution volume at each injection well required to demonstrate an effective breakthrough at the dose-response wells may be estimated with the target ROI of 10 feet, screen interval of 15 feet, and assumed mobile fraction of 10%. Based on the equation below, the anticipated volumes that would be required to achieve breakthrough at 10 feet dose-response wells are estimated at approximately 3,500 gallons per well. These volumes are considered approximate and may be modified in the field depending on the response observed in nearby monitoring wells.

$$V_{inj} = \pi \times {r_{inj}}^2 \times h \times \theta_m$$

Where:

r_{inj} = radius of injection = 10 feet

V_{inj} = volume of injection (cubic feet)

h = the height of the saturated well screen = 15 feet in shallow zone and 15 feet in deep zone

θ_m = the mobile fraction (interconnected pore spaces providing flow) of the formation, initially estimated at 10%; the actual value will be determined based on the observed tracer response during testing

Injection solution samples will be collected from each batch over the course of the injection event and submitted for laboratory analysis of Rhodamine WT dye to confirm concentrations present in the injection solution. The proposed sampling schedule is included in Table 2 and may be adjusted based on the progress of the test. If the tank of solution is clear or allows light to penetrate through, the tank will be covered with a dark tarp to avoid photodegradation of the dye, which could affect the injection concentration.

5.3 Injection Procedures

After the injection solution has been prepared, the injection testing will begin with simultaneous injection in all wells. An EVO/tracer solution will be injected into injection wells PW-1S and PW-2D, and an EVO solution without tracer will be injected into wells PW-1D and PW-2S. Wellhead pressures, injection flow rates, cumulative injection volumes, volumes in the tanks, and periodic field parameter screening in monitoring wells will be recorded in a field log.

A visual dilution standard set will be prepared for each of the two solutions (EVO/dye, EVO alone) and used to evaluate for visual evidence of injection response at monitoring wells during and following the injection activity. These visual observations along with other field parameters (e.g., specific conductance and turbidity) will be used as qualitative indications of injection solution arrival. The injection solution will continue to be injected until the visible response observed at monitoring wells within the target ROI of the injection well (10 feet) stabilize or until a field decision is made to discontinue injection. These results will be used to select samples for quantitative laboratory analysis and to adapt the total injection volume in order to achieve monitoring well breakthrough response. Real-time evaluation of the results during injection will be used to determine when the injection is complete.

Groundwater levels will be recorded during injection to observe changes during the injection and to evaluate the subsequent aquifer recovery to further quantify the hydraulic response that the amendment delivery may have during full-scale ERD implementation. Changes in groundwater levels will be monitored using a water-level meter.

Based on Arcadis' project experience at the Site, the upper aquifer is highly permeable and can receive carbon substrate flow of over 20 gallons per minute with zero observed wellhead pressure. Due to the soil heterogeneities in the former PSA and the presence of less permeable facies, it is anticipated that flow rates may be lower than that observed in other ongoing IRZ areas. During delivery, injection pressures and flow rates will be carefully controlled to avoid creation of conditions that could lead to creation of unintentional preferential flow paths (i.e., fractures) within the formation. The maximum injection pressure during injection will not exceed 5 pounds per square inch. The injection test is anticipated to take approximate 2 to 3 weeks to complete. The actual duration of the injections will depend upon the injection rates achieved, the length of injections per day, and the aquifer-specific volume/distribution characteristics at the Site.

5.4 Pilot Test Monitoring Program

The monitoring program established for the injection test consists of three sampling periods including baseline monitoring, monitoring conducted during the injection, and monitoring conducted following the injection. The objective of this monitoring program is to evaluate and obtain design parameters for full-scale implementation. The groundwater monitoring during injection will consist of water level gauging, field parameter measurements, injection pressure and flow rate monitoring, and groundwater sampling for Rhodamine WT and TOC analysis. The baseline and post-injection monitoring program will consist of site-specific VOCs, methane, ethane, ethene, and biogeochemical parameters (baseline only), in addition to the other parameters monitored during injection test.

A one-time baseline monitoring will include the following:

- Collection of water-levels and field parameters from all the wells in the ERD pilot test well network
- Collection of groundwater samples for site-specific VOC, TOC, Rhodamine WT, biogeochemical parameters (e.g., alkalinity, nitrate, ferrous iron [field filtered], manganese [field filtered], sulfate), methane, ethane, and ethene analyses

An injection monitoring program will be implemented during the injection that will include the following:

- Recording of the injection wellhead pressure, instantaneous flow rate, and cumulative injection volume
- Collection of real-time water quality logging data (e.g., color, field parameters, and water level) from the dose-response wells for evidence of tracer breakthrough
- Collection of breakthrough analytical groundwater samples from dose-response wells 2 to 3 times per week, based on field parameter measurement, and once breakthrough is observed for Rhodamine WT and TOC analysis

A post-injection performance monitoring program will be implemented that will include the following:

- Collection of groundwater samples for laboratory analysis of Rhodamine WT and TOC from all the injection wells
- Collection of groundwater samples for laboratory analysis of site-specific VOCs, methane, ethane, ethene, Rhodamine WT, TOC, and field parameters from all the monitoring wells
- Post-injection sampling will be conducted monthly for up to three months following the completion of injection

Groundwater samples will be collected using the low-flow methodology in accordance with the monitoring program detailed in Table 2. Field parameters will also be measured during each sampling event.

5.4.1 Laboratory Methodology

All groundwater samples collected during the pilot test will be submitted to selected laboratories for analysis. The analytes and analytical methods are summarized below:

- Site-specific VOCs (U.S. EPA Method SW-846 8260)
- TOC (U.S. EPA Method 415.1)
- Alkalinity (U.S. EPA Method 310.1)
- Nitrate (U.S. EPA Method 353.2)

- Sulfate (U.S. EPA Method 300)
- Ferrous iron (field filtered) and manganese (U.S. EPA Method SW846)
- Methane, ethene, and ethane (Method AM20GAX)
- Tracer analysis

Laboratory methodology and quality assurance / quality control (QA/QC) information presented in the amended QAPP (ARCADIS, Inc. 2011a) will be followed during this investigation. Additional samples (duplicates – 1 per 20 samples, equipment blanks – 1 per 20 samples, and matrix spike / matrix spike duplicate – 1 per 20 samples) will be collected and trip blanks added for QA/QC requirements.

5.5 Tracer Sample Handling Methods

Due to the low detection limits for laboratory analysis of Rhodamine WT (normally in parts per trillion ranges), sampling and sample handling must be done carefully to reduce or eliminate cross contamination of different samples. Several general practices and recommendations are presented below:

- Never reuse personal protective equipment such as gloves for sampling at different locations to eliminate cross contamination.
- Never use regular ice for sample refrigeration – re-usable ice packs are recommended. Remove any regular ice (from condensation) if found on the outside of the ice packs and wipe dry before shipping. Secure the re-usable ice packs before shipping to eliminate bouncing around in the cooler.
- Never store samples of significant difference in concentrations in the same cooler. Wipe off any liquid outside of sample vials.
- Always check the tightness of cap on each sample vial before shipping. Leaking from one sample vial may contaminate all the samples in the same cooler.
- If not shipped out at the end of a day, samples shall be kept in a cooler with the re-usable ice packs. Extra ice packs should be kept refrigerated for sample storage at night.

6 INVESTIGATION DERIVED WASTE MANAGEMENT

A designated staging area will be assigned in a secure area for drilling equipment, materials, and investigation derived waste (e.g., soil cuttings, purge water, and decontamination water). In addition, the decontamination area for drilling equipment will be constructed in the same area. Each drum or roll-off container will be properly labeled with pending analysis waste label containing the type of waste (e.g., soil), sample designations for the contents contained, the generator information, boring number, accumulation start and end date, U.S. EPA waste number (if applicable), and Department of Transportation proper shipping name (if applicable). Once the materials are characterized, the containers will be labeled hazardous or non-hazardous. If the material is determined to be hazardous, the material will be relocated to an appropriate temporary storage area to await offsite disposal. The field representative will maintain an inventory of the number of waste containers (hazardous and non-hazardous) generated and staged on-site as part of the pilot test activities. Hazardous waste is not anticipated to be generated during pilot test activities.

Once the materials have been characterized, an off-site disposal facility will be identified. A waste profile and manifest will be completed and submitted to the disposal facility. Each shipment of waste will be thoroughly tracked and recorded.

7 REPORTING AND SCHEDULE

Upon completion of the pilot test, applicable data will be processed, evaluated, and reported in a full-scale ERD design. This design will provide a full-scale design basis for the modified ERD system, including supporting information and ERD pilot test evaluation results. Components of the full-scale ERD design may consist of the following:

- Introduction with Site background, regulatory status, and objectives
- Site setting, current site conditions, and area-specific CSM
- Overview of the ERD approach
- Results of the pilot test
- ERD Design
  - Permitting requirements
  - Well network details
  - Well construction details
  - Baseline sampling and injection details
  - System details (e.g., piping, manifolds)
  - Performance monitoring program
  - Operation and maintenance
- Schedule
- References
- Supporting data tables, figures, and appendices

Field implementation planning and subcontractor procurement are expected to occur after agency approval of this Addendum. The schedule for implementation is expected to be during the second and/or third quarters of 2017. Field implementation will be initiated within approximately 1 to 2 months of Addendum approval. Pilot testing activities (injection and post-injection monitoring) are expected to be completed within 3 to 4 months of initiation of field implementation, barring schedule impacts that are not able to be controlled (e.g., contractor availability, weather).

8 REFERENCES

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TABLES

Table 1
Summary of ERD Pilot Test Well Construction Details
Former Process Sump Area
RACER Trust Moraine Facilities
Moraine, Ohio

Well ID	Top of Screen[1] (ft bgs)	Bottom of Screen[1] (ft bgs)	Screen Diameter[1] (inch)	Screen Material	Casing Material	Well Design	Area
New Injection Wells[2,5]							
PW-1S	25	40	2	SS	PVC	Individual Well	PSA
PW-1D	50	65	2	SS	PVC	Individual Well	PSA
PW-2S	25	40	2	SS	PVC	Nested Well	PSA
PW-2D	50	65	2	SS	PVC	Nested Well	PSA
New Monitoring Wells[2,4,5]							
PW-3S	25	40	2	SS	PVC	Nested Well	PSA
PW-3D	50	65	2	SS	PVC	Nested Well	PSA
PW-4S	25	40	2	SS	PVC	Individual Well	PSA
PW-4D	50	65	2	SS	PVC	Individual Well	PSA
PW-5S	25	40	2	SS	PVC	Nested Well	PSA
PW-5D	50	65	2	SS	PVC	Nested Well	PSA
PW-6S[3]	25	40	2	SS	PVC	Individual Well	Downgradient
PW-6D[3]	50	65	2	SS	PVC	Individual Well	Downgradient
Existing Monitoring Well							
GM-59	25	35	2	PVC	PVC	Individual Well	Downgradient
GM-60	42	52	2	PVC	PVC	Individual Well	Downgradient

NOTES:

1 = Well construction details are approximate and may be adjusted based on field observations during well installation.

2 = Injection wells and new monitoring wells/well pairs will all be installed outside of the former Process Sump Area building.

3 = One new monitoring well pair will be installed downgradient of the former Process Sump Area (across Springboro Pike).

4 = New monitoring wells will be constructed in the same way as injection wells so that they may be used as full-scale injection wells.

5 = Soil lithology will be logged to guide screen interval determination.

ERD = enhanced reductive dechlorination

ft bgs = feet below ground surface

PVC = polyvinyl chloride

SS = stainless steel

Table 2
Summary of ERD Pilot Test Monitoring Program
Former Process Sump Area
RACER Trust Moraine Facilities
Moraine, Ohio

Well Type	Parameters[1,2]	Frequency[1,2]
	Baseline	
Injection wells	CVOCs, ethene, ethane, methane, TOC, biogeochemical parameters[3], tracer, and field parameters[4]	One time prior to start of injection
Monitoring wells (PSA)		
Monitoring wells (Downgradient)		
	Injection	
Injection wells	Injection volume, flow rates, and pressures	Daily
Monitoring wells (PSA)	TOC, tracer, and field parameters	2 – 3 times per week
Injection solution tank	TOC and tracer	Once per week
	Performance Monitoring	
Injection wells	TOC, tracer, and field parameters	Monthly for up to 3 months
Monitoring wells (PSA)	CVOCs, ethene, ethane, methane, TOC, tracer, and field parameters	
Monitoring wells (Downgradient)		

NOTES:

1 = Analytical parameters and sampling frequency may be adjusted based on injection progress and performance monitoring results.

2 = Among collected samples, only select samples will be analyzed based on injection progress and performance monitoring results.

3 = Biogeochemical parameters include alkalinity, nitrate, ferrous iron (field filtered), manganese, and sulfate.

4 = Field parameters include oxidation reduction potential, dissolved oxygen, pH, temperature, conductivity, turbidity, color, and water level.

CVOCs = chlorinated volatile organic compounds

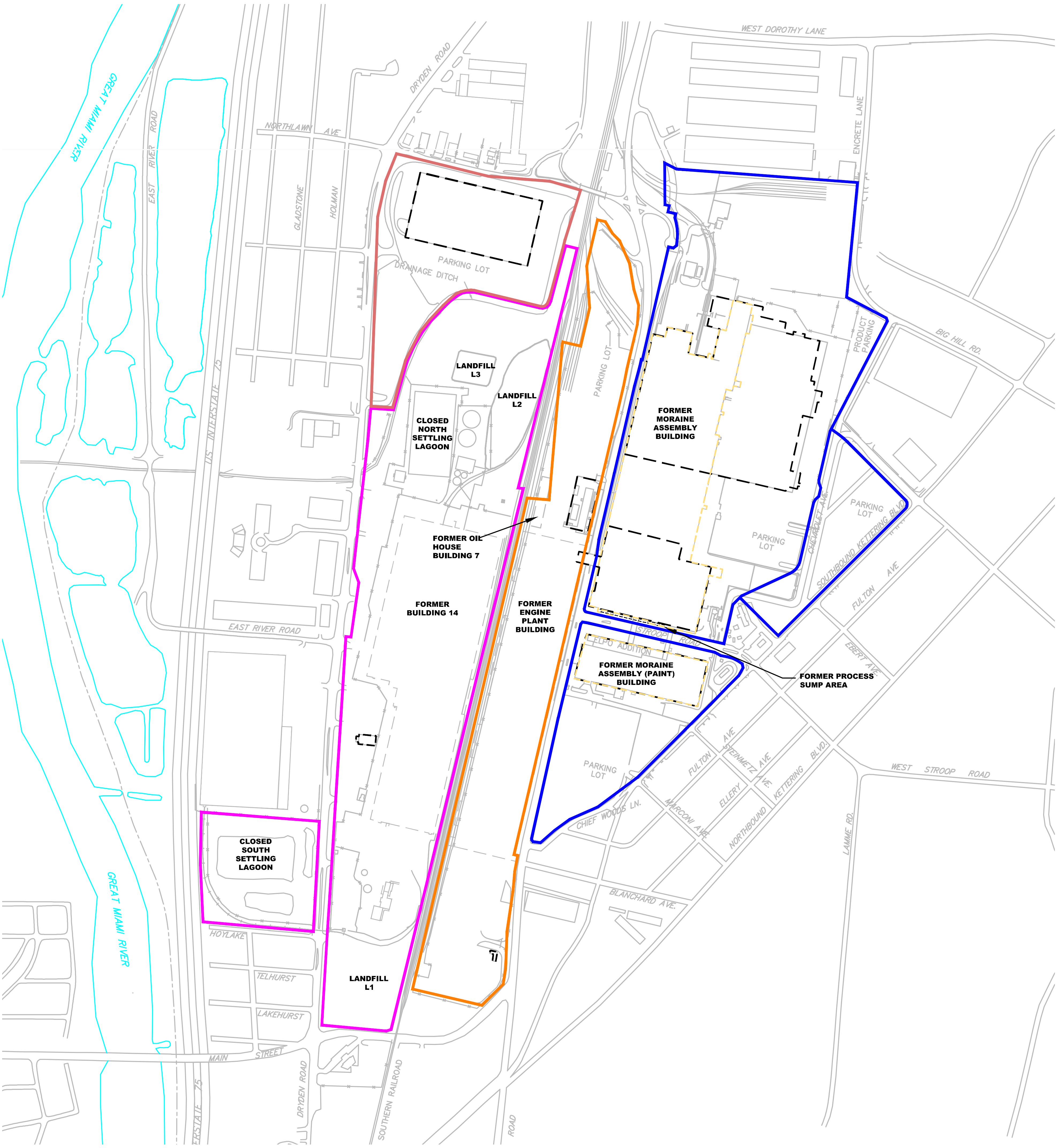
ERD = enhanced reductive dechlorination

PSA = former Process Sump Area

TOC = total organic carbon

FIGURES

CITY:COLUMBUS, OH DIV/GROUP:IM/DV DB:R. SMITH LD:(Opt) PIC:(Opt) PM:J. MANZO TM:T. FORTNER LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Columbus-OH\ACT\OH000294 - RACER\0006B\294-06B-2017-PSA-02.dwg LAYOUT: SITE LAYOUT SAVED: 3/10/2017 8:10 AM ACADVER: 19.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ACAD.CTB PLOTTED: 3/17/2017 1:12 PM BY: SMITH, BOB



LEGEND

- RIVER LEVEE
- FORMER BUILDING FOOTPRINT
- CURRENT BUILDING FOOTPRINT
- SURFACE WATER FEATURE
- FORMER DELPHI HARRISON THERMAL SYSTEMS, MORAINE PLANT PROPERTY BOUNDARY
- FORMER GENERAL MOTORS POWERTRAIN GROUP, MORAINE ENGINE PLANT PROPERTY BOUNDARY
- FORMER GENERAL MOTORS TRUCK GROUP, MORAINE ASSEMBLY PLANT PROPERTY BOUNDARY
- GENERAL MOTORS LLC, DMAX
- FORMER MORAINE ASSEMBLY BUILDINGS

N

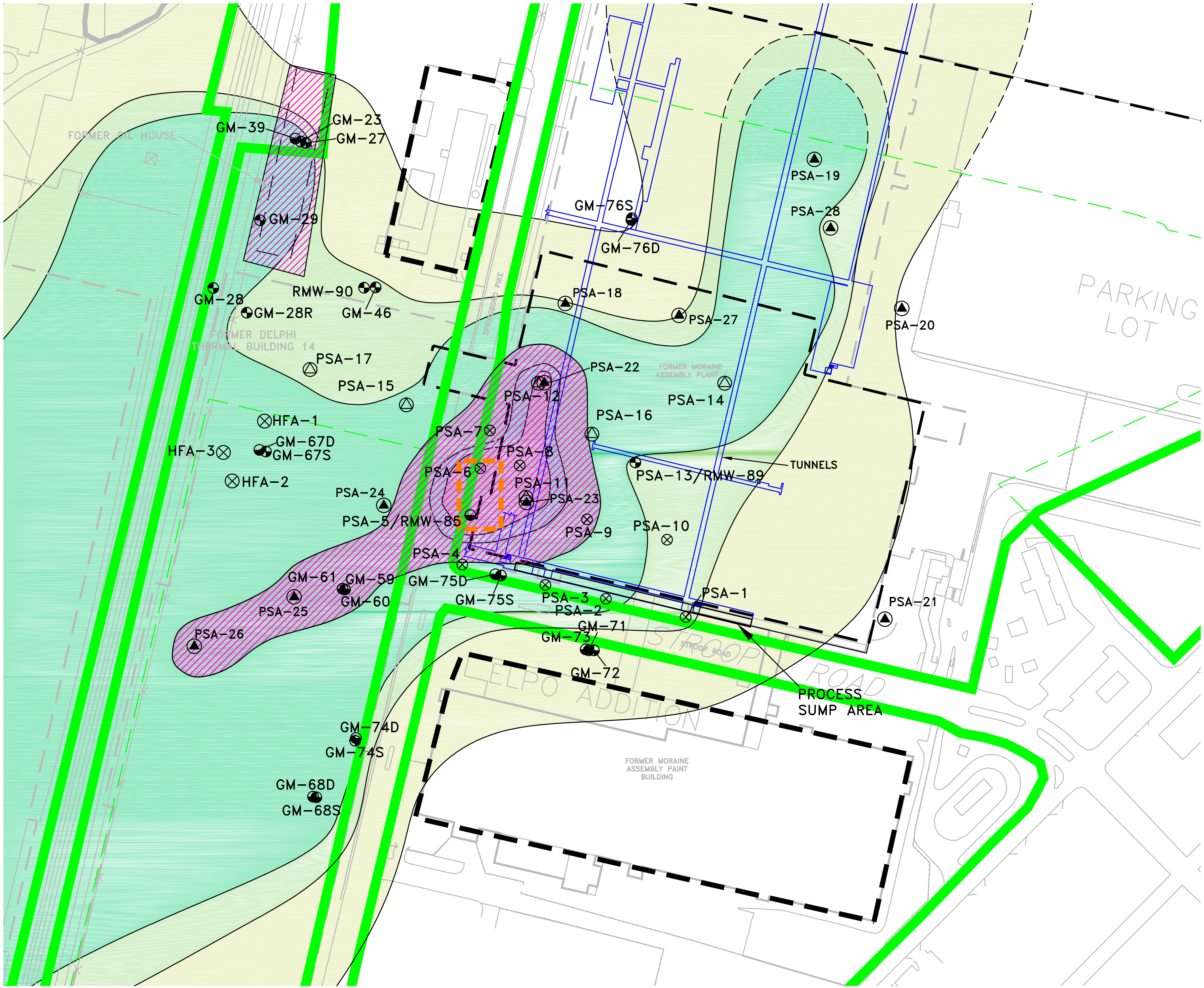
0 200 1000ft

RACER TRUST
MORAINE, OHIO
ERD PILOT TEST WORK PLAN
OH000294.2017

SITE LAYOUT

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1



LEGEND

- PROPERTY BOUNDARY (SOURCE: MONTGOMERY COUNTY AUDITOR'S WEBSITE, FEBRUARY 2015)
- PARCEL BOUNDARY (SOURCE: MONTGOMERY COUNTY AUDITOR'S WEBSITE, FEBRUARY 2015)
- UNDERGROUND TUNNEL
- BORING COMPLETED IN 2015
- BORING COMPLETED IN 2014
- PRE-DESIGN INVESTIGATION BORING LOCATION
- UPPER AQUIFER MONITORING WELL
- LOWER AQUIFER MONITORING WELL
- CURRENT BUILDING FOOTPRINT
- FORMER BUILDING FOOTPRINT
- ug/L MICROGRAMS PER LITER
- >10,000 ug/L
- 5,000–10,000 ug/L
- 1,000–5,000 ug/L
- 100–1,000 ug/L
- 50–100 ug/L
- 5–50 ug/L
- VOC VOLATILE ORGANIC COMPOUNDS
- PILOT TEST AREA
- PROPOSED TREATMENT AREA DURING FULL-SCALE IMPLEMENTATION

NOTE:

1. CONCENTRATIONS POSTED REFLECT 2016 MONITORING WELL RESULTS, 2015 THROUGH 2013 MONITORING WELL RESULTS, PRE-2013 MONITORING WELL RESULTS, AND MAXIMUM CONCENTRATION FROM VERTICAL AQUIFER PROFILING FROM 2011 THROUGH 2015. THE INTERPRETATION OF THE ISOCONCENTRATION INCLUDES THE CONCEPTUAL SITE MODEL UNDERSTANDING (I.E. GROUNDWATER FLOW AND INTERIM MEASURES OPERATION).
2. WHEN SAMPLE RESULT IS NON-DETECT, HALF THE REPORTING LIMIT IS HONORED WITH THE CONTOURING.
3. RELATIVE UNDERSTANDING OF PRE-2013 CONCENTRATIONS (GRAY) WAS USED TO DEVELOP THE OVERALL PLUME GEOMETRY IN THE VICINITY OF THESE WELLS.

DRAFT

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ERD PILOT TEST WORK PLAN
OH000294.2017

TOTAL SITE-SPECIFIC VOC CONCENTRATIONS IN UPPER AQUIFER FORMER PROCESS SUMP AREA

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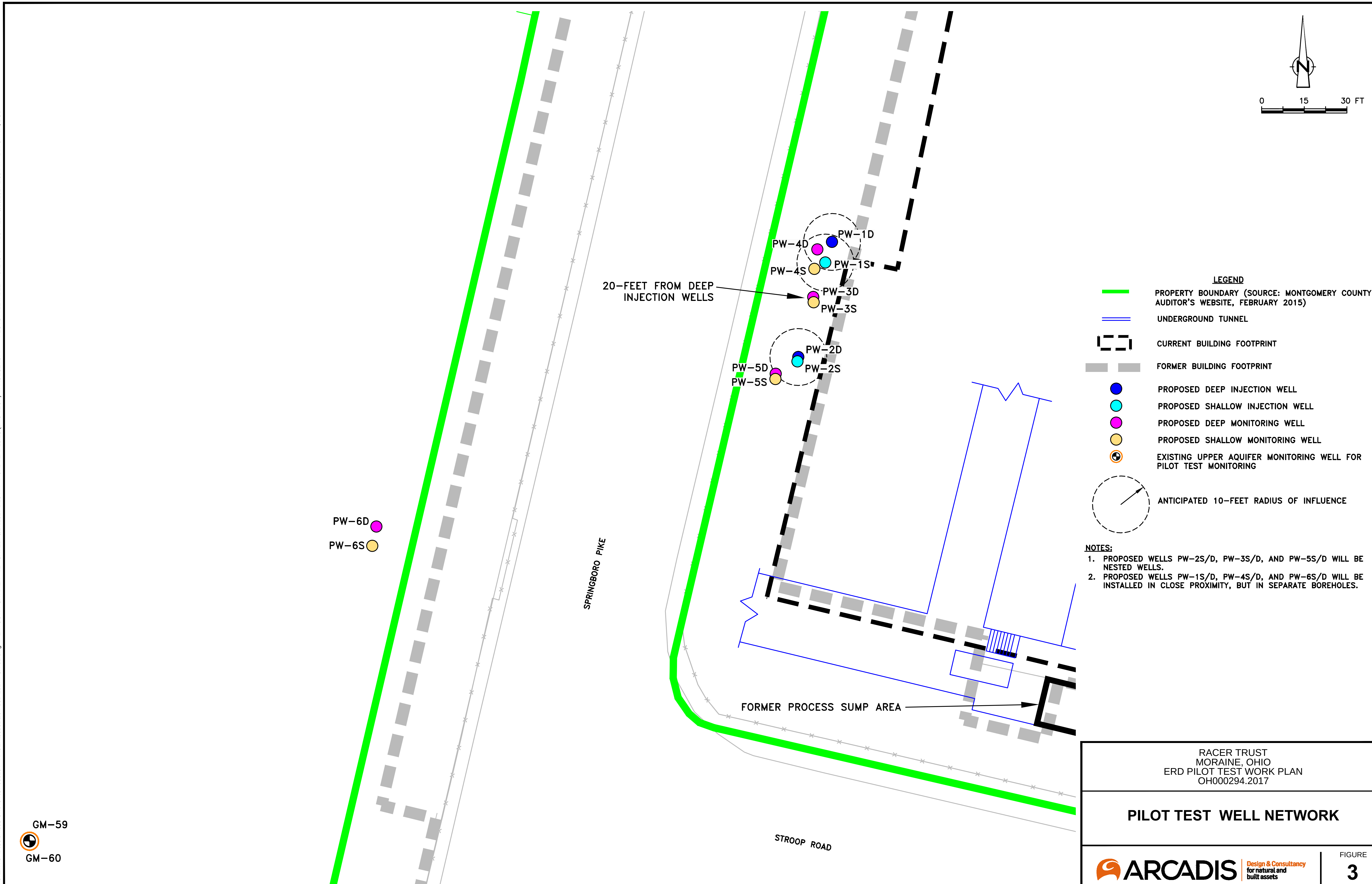
FIGURE
2



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ERD PILOT TEST WORK PLAN
OH000294.2017

PILOT TEST WELL NETWORK

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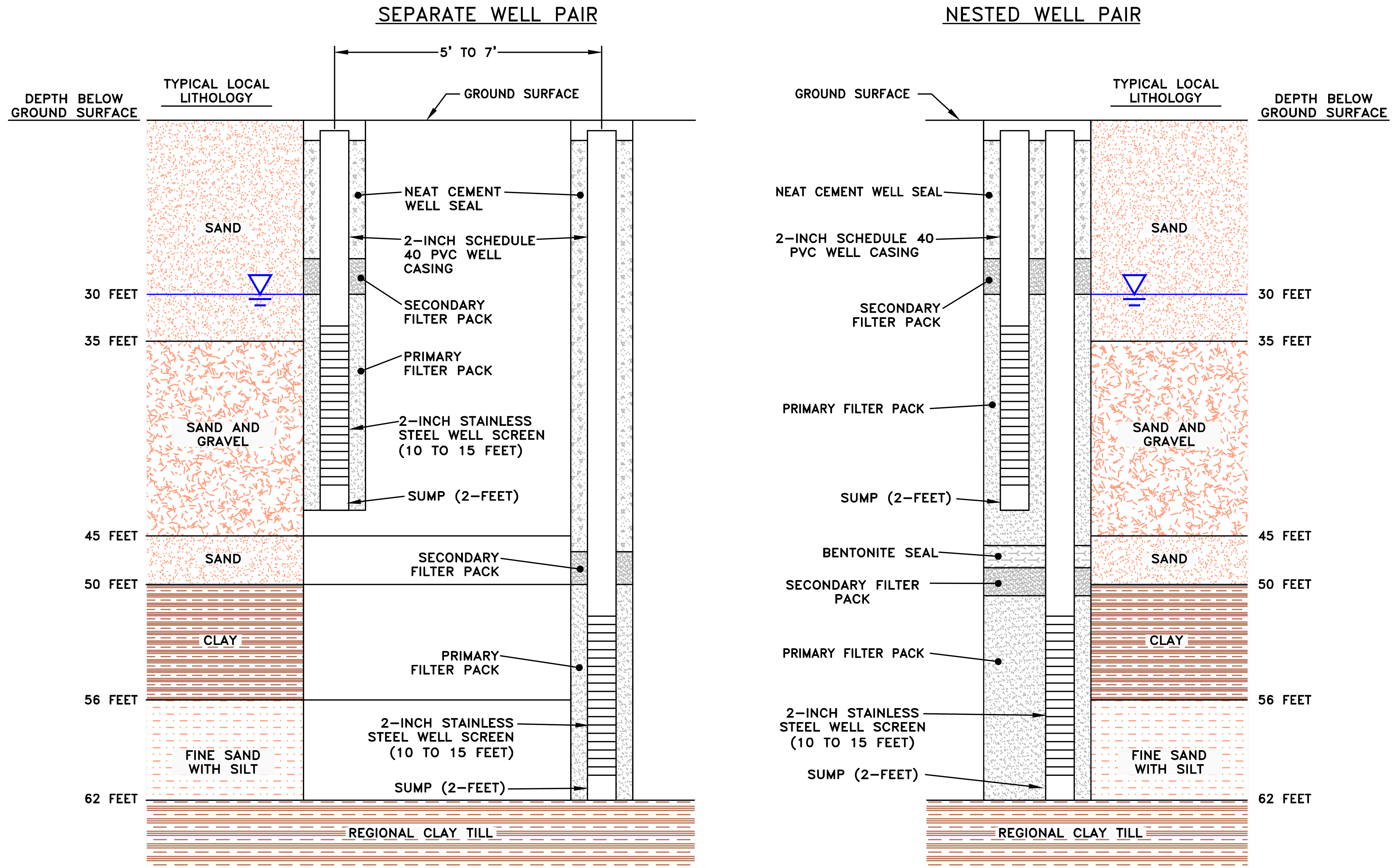
FIGURE 3



NOT TO SCALE

NOTE:

1. WELL SCREEN INTERVALS ARE APPROXIMATE AND MAY BE ADJUSTED BASED ON FIELD OBSERVATION DURING INSTALLATION.

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ERD PILOT TEST WORK PLAN
OH000294.2017

PILOT TEST WELL CONSTRUCTION DETAILS

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FIGURE 4

APPENDIX A

Boring Logs and Well Construction Logs (provided on CD)

ARCADIS

Log of Boring: GM-46

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	N/A	N/A					CONCRETE	
							ML	FILL Brown, clayey silt, gravel (25%), low plasticity, hard, dry	
2	N/A	24	0.0					Same as above	
4	N/A	24	0.0				ML	Same as above	
6	N/A	24	0.0				ML	FILL Gray, clayey silt, sand and gravel (25%), soft, low plasticity, moist	
8	N/A	24	0.0				SW	SAND & GRAVEL Brown, gravel (25%), some silt, trace cobbles, well graded, moist	
10	N/A	24	0.0				SW	Same as above	
12	N/A	24	0.0				SW	Same as above	

☒ Composite Sample to Lab ■ Grab Sample to Lab ▯ Split-Spoon Not Analyzed

Drilling Co.: Prosonic Corporation
Geologist: J. Manzo
Begin Drilling: 2/24/06 @ 1705
Driller: J. Sigler
Total Depth: 32
End Drilling: 2/25/06 @ 1835
Drilling Method: Rotosonic
Surface Elev.: 728.13
Converted to Well: Y Well I.D.: GM-46
Drilling Fluid: Water
North Coor.: 5130.493
East Coor.: 6256.772
Remarks:
Project No.: OH000294.0008.00002
Datum: TOC Elev. 727.79
Filename: February 2006

ARCADIS

Log of Boring: GM-46

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
14	N/A	24	0.0				SW	Same as above	
16	N/A	24	0.0				SW	Same as above	
18	N/A	24	0.0				GW	SAND & GRAVEL Gray, sand (25%), well graded, moist-wet	
20	N/A	24	0.0				GW	Same as above	
22	N/A	24	0.0				ML	CLAYEY SILT Gray, gravel (25%), soft, medium plasticity, wet	▼
24	N/A	24	0.0				ML	Same as above	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Prosonic Corporation
Geologist: J. Manzo
Begin Drilling: 2/24/06 @ 1705
Driller: J. Sigler
Total Depth: 32
End Drilling: 2/25/06 @ 1835
Drilling Method: Rotosonic
Surface Elev.: 728.13
Converted to Well: Y Well I.D.: GM-46
Drilling Fluid: Water
North Coor.: 5130.493
East Coor.: 6256.772
Remarks:
Project No.: OH000294.0008.00002
Datum: TOC Elev. 727.79
Filename: February 2006

ARCADIS

Log of Boring: GM-46

General Motors Corporation

Moraine, Ohio

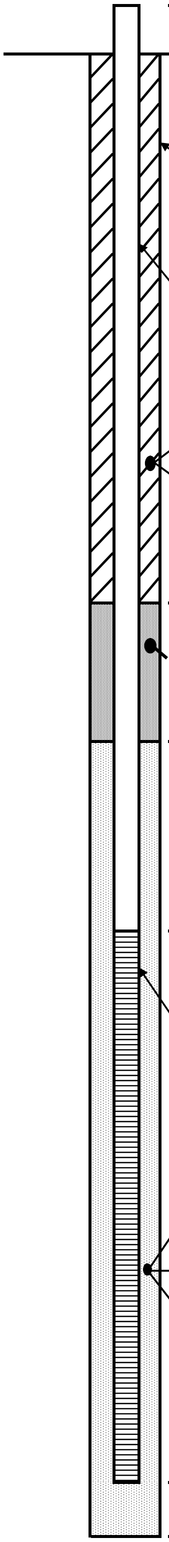
Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
								Water sample collected at 25' for analysis of site-specific VOCs.	
26	N/A	24	0.0				ML	Same as above	
28	N/A	24	0.0				CL	SILTY CLAY Gray, hard, gravel (25%), moist to dry	
30	N/A	24	0.0				CL	Same as above	
32								End of boring	
34									
36									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Prosonic Corporation
Geologist: J. Manzo
Begin Drilling: 2/24/06 @ 1705
Driller: J. Sigler
Total Depth: 32
End Drilling: 2/25/06 @ 1835
Drilling Method: Rotosonic
Surface Elev.: 728.13
Converted to Well: Y Well I.D.: GM-46
Drilling Fluid: Water
North Coor.: 5130.493
East Coor.: 6256.772
Remarks:
Project No.: OH000294.0008.00002
Datum: TOC Elev. 727.79
Filename: February 2006

ARCADIS

Well Construction Log
(Unconsolidated)



-0.5 ft
LAND SURFACE

6 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement/Bentonite

15 ft*

Bentonite ☐ slurry ☒ pellets

17.5 ft*

19.82 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

29.82 ft*

32 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project: General Motors Corporation Well: GM-46

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

728.13 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 2/24-2/25/06

Drilling Method: Rotosonic

Drilling Contractor: Prosonic Corporation

Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump 2/25/06

Fluid Loss During Drilling: NA gallons

Water Removed During Development: 200 gallons

Static Depth to Water: 20.27 feet below M.P.

Pumping Depth to Water: 20.27 feet below M.P.

Pumping Duration: 3.00 hours

Yield: 3 gpm Date: 2/25/06

Specific Capacity: N/A gpm/ft

Well Purpose: Monitoring Well

Remarks: TOC Elevation = 727.79

Prepared by: J. Manzo

ARCADIS

Log of Boring: GM-58

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
							CL	SILTY CLAY Gray, soft, medium plasticity, fine gravel 5%, dry	
	N/A	24	17.0				CL	Same as above	
52									
	N/A	24	17.1				CL	Same as above	
54							SP	SAND Gray, fine, poorly graded	
	N/A	24	16.7				CL	SANDY CLAY Gray, fine-medium sand, stiff, low plasticity, dry	
56									
	N/A	24	17.2				CL	Same as above	
58							CL	SILTY CLAY Dark gray, fine-medium gravel (5%), trace organic material, stiff, low plasticity, dry	
	N/A	24	18.2				CL	Same as above	
60							CL	SILTY CLAY Brown, soft, medium plasticity, moist-dry	
	N/A	24	22.4				CL	Same as above	
62									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 8/21/06 @ 1648

Driller: K. Gobell   Total Depth: 115   End Drilling: 8/22/06 @ 1630

Drilling Method: Rotosonic   Surface Elev.: 735.588   Converted to Well: Y   Well I.D.: GM-58

Drilling Fluid: Water   North Coor.: 3450.80045   East Coor.: 7183.08786

Remarks: Water samples 25-30'; 75-80'; 95-100'

Project No.: OH000294.0009   Datum: TOC Elev=735.462   Filename: August 2006

ARCADIS

Log of Boring: GM-58

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	17.5				CL	Same as above	
64									
	N/A	24	17.5				CL	SILTY CLAY Gray, very stiff, low-medium plasticity, fine gravel (5-10%), dry	
66									
	N/A	24	18.1				CL	Same as above	
68									
	N/A	24	15.5				CL	Same as above	
70							SP	SAND Brown, fine-medium, little silt, wet	
	N/A	24	N/A					No recovery	
72								No recovery	
	N/A	24	N/A					No recovery	
74									
	N/A	24	0.0				GP	GRAVEL	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 8/21/06 @ 1648

Driller: K. Gobell   Total Depth: 115   End Drilling: 8/22/06 @ 1630

Drilling Method: Rotosonic   Surface Elev.: 735.588   Converted to Well: Y   Well I.D.: GM-58

Drilling Fluid: Water   North Coor.: 3450.80045   East Coor.: 7183.08786

Remarks: Water samples 25-30'; 75-80'; 95-100'

Project No.: OH000294.0009   Datum: TOC Elev=735.462   Filename: August 2006

Log of Boring: GM-58

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
76								Brown, fine-medium, coarse sand (10-20%), poorly graded, wet	
	N/A	24	0.0				SP	SAND Brown, medium-coarse, poorly graded, wet	
78									
	N/A	24	0.0				SP	Same as above	
80									
	N/A	24	0.0				GW	GRAVEL Brown, fine, medium-coarse sand (30%), wet	
82									
	N/A	24	0.0				SW	SAND Brown, medium-coarse, fine gravel (30%), well graded, wet	
84							SW	Same as above	
	N/A	24	0.0				SP	SAND Olive gray, fine-medium, poorly graded, wet	
86									
	N/A	24	0.0				SP	Same as above	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 8/21/06 @ 1648

Driller: K. Gobell   Total Depth: 115   End Drilling: 8/22/06 @ 1630

Drilling Method: Rotosonic   Surface Elev.: 735.588   Converted to Well: Y Well I.D.: GM-58

Drilling Fluid: Water   North Coor.: 3450.80045   East Coor.: 7183.08786

Remarks: Water samples 25-30'; 75-80'; 95-100'

Project No.: OH000294.0009   Datum: TOC Elev=735.462   Filename: August 2006

Log of Boring: GM-58

General Motors Corporation
Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
88									
	N/A	24	0.0				SP	Same as above	
90									
	N/A	24	0.0				SP	Same as above	
92									
	N/A	24	0.0				SP	Same as above	
94									
	N/A	24	0.0				SP	Same as above	
96							SP	Same as above	
	N/A	24	0.0				SP	Same as above, gray	
98									
	N/A	24	0.0				SP	Same as above	
100									

☒ Composite Sample to Lab ■ Grab Sample to Lab ▯ Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/21/06 @ 1648
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/22/06 @ 1630
Drilling Method: Rotosonic
Surface Elev.: 735.588
Converted to Well: Y Well I.D.: GM-58
Drilling Fluid: Water
North Coor.: 3450.80045
East Coor.: 7183.08786
Remarks: Water samples 25-30'; 75-80'; 95-100'
Project No.: OH000294.0009
Datum: TOC Elev=735.462
Filename: August 2006

Log of Boring: GM-58

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0				SW	SAND Brown, fine-coarse, trace fine-medium gravel, well graded, wet	
102									
	N/A	24	0.0				SW	Same as above	
104									
	N/A	24	13.1				GW	GRAVEL Gray, fine-medium, fine-coarse sand (30%), well graded, wet	
106									
	N/A	24	13.2				GW	Same as above	
108							GW	Same as above	
	N/A	24	2.4				GW	Same as above	
110									
	N/A	24	0.7				GW	Same as above	
112									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 8/21/06 @ 1648

Driller: K. Gobell | Total Depth: 115 | End Drilling: 8/22/06 @ 1630

Drilling Method: Rotosonic | Surface Elev.: 735.588 | Converted to Well: Y Well I.D.: GM-58

Drilling Fluid: Water | North Coor.: 3450.80045 | East Coor.: 7183.08786

Remarks: Water samples 25-30'; 75-80'; 95-100'

Project No.: OH000294.0009 | Datum: TOC Elev=735.462 | Filename: August 2006

Log of Boring: GM-58

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	2.1				GW	Same as above	
114									
								End of boring	
116									
118									
120									
122									
124									

Composite Sample to Lab Grab Sample to Lab Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear Geologist: T. Fortner Begin Drilling: 8/21/06 @ 1648

Driller: K. Gobell Total Depth: 115 End Drilling: 8/22/06 @ 1630

Drilling Method: Rotosonic Surface Elev.: 735.588 Converted to Well: Y Well I.D.: GM-58

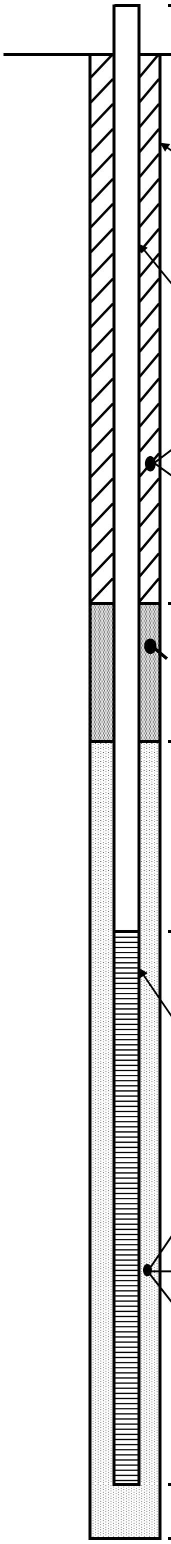
Drilling Fluid: Water North Coor.: 3450.80045 East Coor.: 7183.08786

Remarks: Water samples 25-30'; 75-80'; 95-100'

Project No.: OH000294.0009 Datum: TOC Elev=735.462 Filename: August 2006

ARCADIS

Well Construction Log
(Unconsolidated)



-0.5 ft LAND SURFACE

6 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement/Bentonite

68 ft*

Bentonite ☐ slurry
70 ft* ☐ pellets

72 ft*

Well Screen.
2 inch diameter
Schedule 40, 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

82 ft*

82 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-58

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

735.588 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 9/1/2006

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Pumping - surge with pump 9/1/06

Fluid Loss During Drilling: NM gallons

Water Removed During Development: NM gallons

Static Depth to Water: 28.32 feet below M.P.

Pumping Depth to Water: 79 feet below M.P.

Pumping Duration: NM hours

Yield: NM gpm Date: NA

Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well - Well I

Remarks: TOC Elevation = 735.462

Time: 1600, 1610, 1615, 1620, 1625, 1630

pH: 6.78, 6.61, 6.61, 6.58, 6.59, 6.59

Conductivity: 1.20, 1.20, 1.20, 1.21, 1.20, 1.20

Turbidity: 232, 137, 72, 36, 28, 18

Temp: 17.8, 17.3, 17.5, 17.4, 17.3, 17.4

Prepared by: J. Manzo/ J. Wallace

ARCADIS

Log of Boring: GM-59

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								See GM-61 for lithologic description from 0-35'	
2									
4									
6									
8									
10									
12									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: A. Jacobs   Begin Drilling: 8/30/06

Driller: K. Gobell   Total Depth: 35   End Drilling: 8/30/06

Drilling Method: Rotosonic   Surface Elev.: 732.464   Converted to Well: Y Well I.D.: GM-59

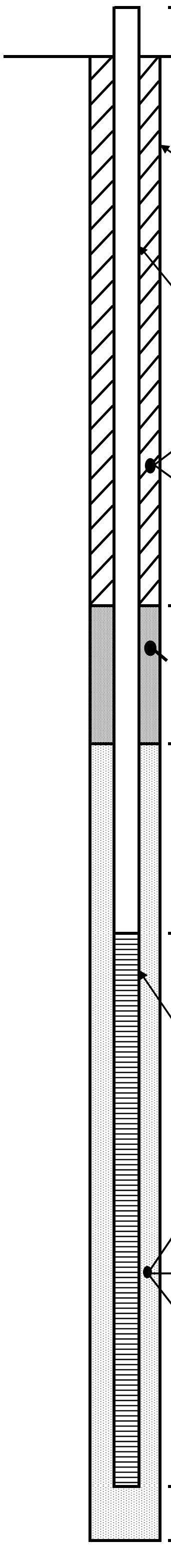
Drilling Fluid: Water   North Coor.: 4501.29894   East Coor.: 6323.48631

Remarks: Shallow nested pair to GM-60.

Project No.: OH000294.0008.00002   Datum: TOC Elev 732.246   Filename: July 2006

ARCADIS

Well Construction Log
(Unconsolidated)



-0.5 ft
LAND SURFACE

8 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement/Bentonite

21 ft*

Bentonite ☐ slurry ☐ pellets

23 ft*

25 ft*

Well Screen.
2 inch diameter
Schedule 40, 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

35 ft*

35 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-59

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

732.464 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 8/30/2006

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Pumping - surge with pump 9/1/06

Fluid Loss During Drilling: ~50 gallons

Water Removed During Development: 56.8 gallons

Static Depth to Water: 25.8 feet below M.P.

Pumping Depth to Water: 24.9 feet below M.P.

Pumping Duration: 35.22 hours

Yield: 0.62 gpm Date: 9/1/06

Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well - Well J (Shallow)

Remarks: TOC Elevation = 732.246

Time 10:55, 10:58, 11:01, 11:04

pH 6.69, 6.67, 6.66, 6.67

Conductivity 1.43, 1.34, 1.33, 1.34

Temperature 18.4, 18.4, 18.5, 18.5

Turbidity 76, 53, 35, 27

Prepared by: A.Jacobs

ARCADIS

Log of Boring: GM-60

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0								See GM-61 for lithologic description from 0-52'	
2									
4									
6									
8									
10									
12									

☒ Composite Sample to Lab ■ Grab Sample to Lab ▯ Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: A. Jacobs
Begin Drilling: 8/30/06

Driller: K. Gobell
Total Depth: 52
End Drilling: 8/30/06

Drilling Method: Rotosonic
Surface Elev.: 732.464
Converted to Well: Y Well I.D.: GM-60

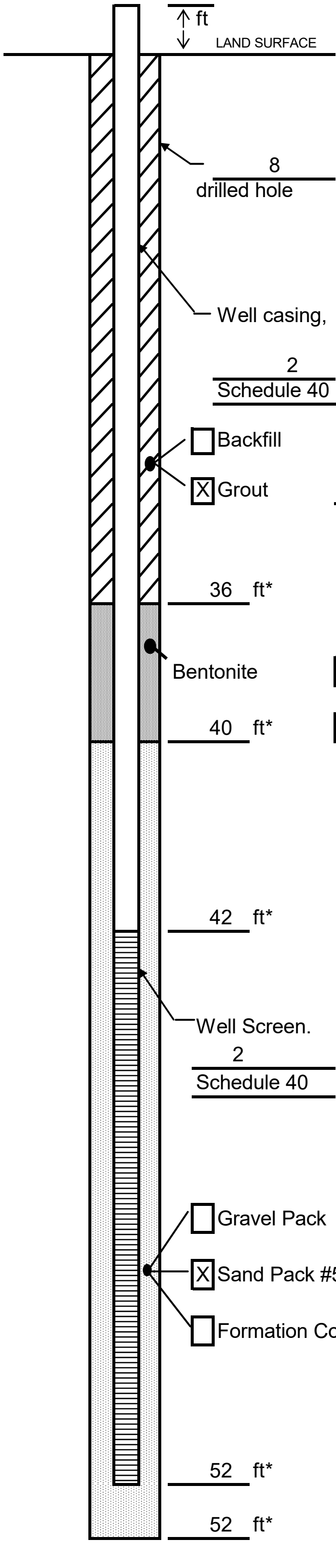
Drilling Fluid: Water
North Coor.: 4701.07762
East Coor.: 6323.54823

Remarks: Intermediate nested pair to GM-59.

Project No.: OH000294.0008.00002 Datum: TOC Elev 732.237 Filename: July 2006

ARCADIS

Well Construction Log
(Unconsolidated)



-0.5 ft

LAND SURFACE

8 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement/Bentonite

36 ft*

Bentonite ☐ slurry ☒ pellets

40 ft*

42 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

52 ft*

52 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-60

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

732.464 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 8/30/2006

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Pumping - surge with pump 9/1/06

Fluid Loss During Drilling: ~50 gallons

Water Removed During Development: ~80 gallons

Static Depth to Water: 25.8 feet below M.P.

Pumping Depth to Water: 24.8 feet below M.P.

Pumping Duration: 0.83 hours

Yield: 0.62 gpm Date: 9/1/06

Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well-Well J (Intermediate)

Remarks: TOC Elevation = 732.237

Time 11:48, 11:52, 11:55, 11:58

Temperature 19.2, 19.1, 19.2, 19.1

Condictivity 1.23, 1.22, 1.22, 1.22

pH 6.66, 6.68, 6.65, 6.67

Turbidity 9, 7, 6, 4

Prepared by: A. Jacobs / J. Wallace

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	0.0					ASPHALT/CONCRETE	
2							SW	SAND Brown, fine-coarse, fine-coarse gravel (40%), well graded, wet	
4	N/A	24	0.3				SW	SAND Brown, fine-medium, fine gravel (5%), well graded, moist-dry	
6							SW	SAND Yellowish brown, fine-coarse, fine-coarse gravel (40%), well graded, dry	
	N/A	24	1.4				SW	Same as above, fine-medium gravel (30%)	
8	N/A	24	0.0				SW	Same as above	
10	N/A	24	0.0				SW	Same as above	
12							SW	Same as above	

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 8/23/06 @ 1015

Driller: K. Gobell | Total Depth: 115 | End Drilling: 8/24/06 @ 0940

Drilling Method: Rotosonic | Surface Elev.: 732.483 | Converted to Well: Y Well I.D.: GM-61

Drilling Fluid: Water | North Coor.: 4501.21590 | East Coor.: 6318.06175

Remarks: Water samples 30-35'; 47-52'; 70-75'

Project No.: OH000294.0009 | Datum: TOC Elev. 732.225 | Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0				SW	Same as above	
14									
	N/A	24	0.4				SW	Same as above, medium-coarse sand, fine- medium gravel (40%)	
16									
	N/A	24	0.0				SW	Same as above	
18									
	N/A	24	0.0				SW	Same as above	
20									
	N/A	24	0.0				SW	SAND/GRAVEL Yellow brown, medium-coarse sand, fine-coarse gravel (50%), well graded, moist	
22									
	N/A	24	0.0				SW	SAND Light gray, fine-medium, fine-coarse gravel (30%), well graded, dry	
24							SW	Same as above	

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic
Surface Elev.: 732.483
Converted to Well: Y Well I.D.: GM-61
Drilling Fluid: Water
North Coor.: 4501.21590
East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009
Datum: TOC Elev. 732.225
Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0				GW	GRAVEL Yellow brown, fine-coarse, coarse sand (20%), well graded, wet	
26									
	N/A	24	0.0				GW	Same as above	
28									
	N/A	24	0.0				GW	Same as above	
30									
	N/A	24	6.1				GW	Same as above	
32									
	N/A	24	3.2				SW	SAND Yellow brown, medium-coarse, fine-coarse gravel (10%), well graded, wet	
34									
	N/A	24	13.0				GW	Same as above	
36							GW	Same as above	
	N/A	24	12.8				GW	Same as above	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic
Surface Elev.: 732.483
Converted to Well: Y Well I.D.: GM-61
Drilling Fluid: Water
North Coor.: 4501.21590
East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009
Datum: TOC Elev. 732.225
Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
38	N/A	24	12.5				GW	Same as above with little silt	
40	N/A	24	11.8				GW	Same as above	
42	N/A	24	5.8				GW	Same as above	
44	N/A	24	15.1				GW	Same as above	
46	N/A	24	14.5				GW	Same as above	
48							GW	Same as above	
	N/A	24	13.9				GW	Same as above	
50									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic
Surface Elev.: 732.483
Converted to Well: Y Well I.D.: GM-61
Drilling Fluid: Water
North Coor.: 4501.21590
East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009
Datum: TOC Elev. 732.225
Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	19.7				GW	Same as above	
52							CL	SILTY CLAY Yellowish orange, trace medium gravel, low plasticity, stiff, dry	
	N/A	24	15.3				CL	Same as above	
54									
	N/A	24	0.0				CL	SILTY CLAY Gray, very stiff, dry, low plasticity, fine-medium gravel (5%), dry	
56									
	N/A	24	0.0				CL	Same as above	
58									
	N/A	24	0.0				CL	Same as above	
60							CL	Same as above	
	N/A	24	0.0				CL	Same as above	
62									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 8/23/06 @ 1015

Driller: K. Gobell | Total Depth: 115 | End Drilling: 8/24/06 @ 0940

Drilling Method: Rotosonic | Surface Elev.: 732.483 | Converted to Well: Y Well I.D.: GM-61

Drilling Fluid: Water | North Coor.: 4501.21590 | East Coor.: 6318.06175

Remarks: Water samples 30-35'; 47-52'; 70-75'

Project No.: OH000294.0009 | Datum: TOC Elev. 732.225 | Filename: August 2006

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0				CL	Same as above	
64									
	N/A	24	0.0				CL	SANDY CLAY Brown, fine sand, very stiff, low plasticity, dry	
66									
	N/A	24	0.0				SW	SAND Brown, fine-medium, fine gravel (10%), well graded, wet	
68									
	N/A	24	0.0				SW	Same as above	
70									
	N/A	24	0.0				SP	Same as above, no gravel	
72							SP	Same as above	
	N/A	24	0.0				SP	Same as above	
74									
	N/A	12	0.0				SW	SAND	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed   *Page 6 of 10*

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell   Total Depth: 115   End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic   Surface Elev.: 732.483   Converted to Well: Y   Well I.D.: GM-61
Drilling Fluid: Water   North Coor.: 4501.21590   East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009   Datum: TOC Elev. 732.225   Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
								Brown, fine-coarse gravel and cobbles (20%), well graded, wet	
76									
	N/A	12	0.0				SW	Same as above	
78									
	N/A	12	0.0				SW	Same as above	
80									
	N/A	12	0.0				SW	Same as above	
82									
	N/A	12	0.0				SW	Same as above, gravel and cobbles (25%)	
84							SW	Same as above	
	N/A	12	0.0				SW	Same as above	
86									
	N/A	12	0.0				SW	Same as above	

Composite Sample to Lab ■ Grab Sample to Lab Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic
Surface Elev.: 732.483
Converted to Well: Y Well I.D.: GM-61
Drilling Fluid: Water
North Coor.: 4501.21590
East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009
Datum: TOC Elev. 732.225
Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
88									
	N/A	12	0.0				SW	Same as above	
90									
	N/A	12	0.0				SW	Same as above	
92									
	N/A	12	0.0				SW	Same as above	
94									
	N/A	18	0.0				SW	Same as above	
96							SW	Same as above	
	N/A	18	0.0				SW	Same as above	
98									
	N/A	18	0.0				SW	Same as above	
100									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 8/23/06 @ 1015

Driller: K. Gobell   Total Depth: 115   End Drilling: 8/24/06 @ 0940

Drilling Method: Rotosonic   Surface Elev.: 732.483   Converted to Well: Y Well I.D.: GM-61

Drilling Fluid: Water   North Coor.: 4501.21590   East Coor.: 6318.06175

Remarks: Water samples 30-35'; 47-52'; 70-75'

Project No.: OH000294.0009   Datum: TOC Elev. 732.225   Filename: August 2006

ARCADIS

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	18	0.0				SW	Same as above	
102									
	N/A	18	0.0				SW	Same as above	
104									
	N/A	18	0.0				SW	Same as above	
106									
	N/A	18	0.0				SW	Same as above	
108							SW	Same as above	
	N/A	18	0.0				SW	Same as above	
110									
	N/A	18	0.0				SW	Same as above	
112									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 8/23/06 @ 1015

Driller: K. Gobell | Total Depth: 115 | End Drilling: 8/24/06 @ 0940

Drilling Method: Rotosonic | Surface Elev.: 732.483 | Converted to Well: Y Well I.D.: GM-61

Drilling Fluid: Water | North Coor.: 4501.21590 | East Coor.: 6318.06175

Remarks: Water samples 30-35'; 47-52'; 70-75'

Project No.: OH000294.0009 | Datum: TOC Elev. 732.225 | Filename: August 2006

Log of Boring: GM-61

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	18	0.0				SW	Same as above	
114									
								End of boring	
116									
118									
120									
122									
124									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 8/23/06 @ 1015
Driller: K. Gobell
Total Depth: 115
End Drilling: 8/24/06 @ 0940
Drilling Method: Rotosonic
Surface Elev.: 732.483
Converted to Well: Y Well I.D.: GM-61
Drilling Fluid: Water
North Coor.: 4501.21590
East Coor.: 6318.06175
Remarks: Water samples 30-35'; 47-52'; 70-75'
Project No.: OH000294.0009
Datum: TOC Elev. 732.225
Filename: August 2006

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	N/A					ASPHALT	
							FILL	CONCRETE WITH REBAR	
2	N/A	24	0.0				SW	SAND WITH GRAVEL Brown, fine-coarse, well graded, subrounded to subangular, 20% fine-coarse gravel, rounded, dry (fill)	
4	N/A	24	0.0						
6									
	N/A	24	0.0						
8								Note: concrete @ 8'	
	N/A	24	0.0					Note: Light brown, 10% gravel, damp @ 9'	
10									
	N/A	24	0.0						
12									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 3/27/2007
Driller: Gerald Sealey
Total Depth: 121
End Drilling: 3/27/2007
Drilling Method: Rotosonic
Surface Elev.: 732.644
Converted to Well: Y Well I.D.: GM-67D
Drilling Fluid: Water
North Coor.: 4744.47186
East Coor.: 6082.03970
Remarks:
Project No.: OH000294.0010
Datum: TOC: 732.188
Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Soil Class.	Description
13	N/A	24	0.0		Note: 5% fine-medium rounded gravel, dry
15	N/A	24	0.0		
17	N/A	24	0.0		
19	N/A	24	0.0	SW	SAND Light brown, fine-coarse, well graded, 10% fine-coarse rounded gravel, moist
				GW	GRAVEL WITH SAND Brown, fine-coarse, well graded, subround to rounded, 45% medium coarse sand, subround-subangular, wet
21	N/A	24	0.0		GRAVEL WITH SAND Brown, fine-coarse, well graded, subround to rounded, 45% medium coarse sand, subround-subangular, wet
22					GRAVEL WITH SAND Brown, fine-coarse, well graded, subround to round, 50% medium-coarse sand, subround-subangular. Note: 2" sandy clay @ 22.1' and 22.5', soft, high plasticity, medium sand 30%, wet
23	N/A	24	0.0		Water sample 22.5-27.5' @ 1528
					GRAVEL WITH SAND Brown, fine-coarse, well graded, subround to round, 50% medium-coarse sand, subround-subangular
				SW	SAND Brown, medium-coarse, well graded, subangular, 10% fine-medium

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 3/27/2007

Driller: Gerald Sealey | Total Depth: 121 | End Drilling: 3/27/2007

Drilling Method: Rotosonic | Surface Elev.: 732.644 | Converted to Well: Y Well I.D.: GM-67D

Drilling Fluid: Water | North Coor.: 4744.47186 | East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010 | Datum: TOC: 732.188 | Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0					subrounded, gravel, wet	
26									
	N/A	24	0.0					Note: Gravel with subrounded-subangular, 10% fine medium subrounded sand @ 27-27.5'	
								Note: subrounded-subangular sand with 15% fine-medium subrounded gravel @ 27.5-29'	
28									
	N/A	24	0.0					Note: Cobble fossiliferous limestone 29- 29.5'	
							CL	SILTY CLAY Gray, very stiff, low plasticity, with 10% coarse subangular sand and fine subrounded gravel, dry	
30									
	N/A	24	0.0						
32									
	N/A	24	0.0						
34									
	N/A	24	0.0						
36									
	N/A	24	0.0				CL	SILTY CLAY Gray, stiff, medium plasticity, 5% coarse subangular sand and fine gravel,	

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 3/27/2007
Driller: Gerald Sealey
Total Depth: 121
End Drilling: 3/27/2007
Drilling Method: Rotosonic
Surface Elev.: 732.644
Converted to Well: Y Well I.D.: GM-67D
Drilling Fluid: Water
North Coor.: 4744.47186
East Coor.: 6082.03970
Remarks:
Project No.: OH000294.0010
Datum: TOC: 732.188
Filename: April 2007

Log of Boring: GM-67D

General Motors Corporation   Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
38								moist-dry	
	N/A	24	0.0					Note: Gravel fine-medium grained, dry @ 39'	
40									
	N/A	24	0.0						
42									
	N/A	24	0.0						
44									
	N/A	24	0.0				GP	GRAVEL WITH SAND Olive gray, poorly graded, fine-medium, subangular, 25% coarse sand, wet	
46								Water sample 46-51' @ 1043	
	N/A	24	0.0				SW	SAND Olive gray, well graded, medium-coarse, subangular, 10% fine gravel, subrounded, wet	
48									
	N/A	24	0.0					SAND Olive gray, well graded, medium-coarse, subangular, 10% fine gravel, subrounded, wet	
50									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 3/27/2007

Driller: Gerald Sealey   Total Depth: 121   End Drilling: 3/27/2007

Drilling Method: Rotosonic   Surface Elev.: 732.644   Converted to Well: Y   Well I.D.: GM-67D

Drilling Fluid: Water   North Coor.: 4744.47186   East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010   Datum: TOC: 732.188   Filename: April 2007

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0				GW	SANDY GRAVEL Olive gray, well graded, fine-coarse, subrounded with 10% medium-coarse subangular sand, wet	
							CL	SILTY CLAY Gray, medium-stiff, medium plasticity, 5% fine-medium gravel, moist	
52	N/A	24	0.0				SP	SAND Olive gray, poorly graded, fine with 5% coarse, wet	
								SAND Olive gray, poorly graded, fine with 5% coarse, wet	
54	N/A	24	0.0				CL	SILTY CLAY Gray, very stiff, medium plasticity, 5% fine-medium subangular gravel, dry	
56	N/A	24	0.8					SANDY CLAY Gray, very stiff, medium plasticity, 5% fine subangular gravel, sand in fine 20%, moist	
58	N/A	24	1.1					Note: gravel fine-medium, dry @ 59'	
60	N/A	24	0.3						
62									

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 3/27/2007

Driller: Gerald Sealey   Total Depth: 121   End Drilling: 3/27/2007

Drilling Method: Rotosonic   Surface Elev.: 732.644   Converted to Well: Y   Well I.D.: GM-67D

Drilling Fluid: Water   North Coor.: 4744.47186   East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010   Datum: TOC: 732.188   Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.5						
64								Note: Black organic material @ 64'. Fine sand 40% @ 64-65'.	
	N/A	24	3.7				GW	GRAVEL WITH SAND Gray, well graded, fine-medium subrounded-rounded, 25% medium-coarse sand, subrounded-subangular, wet	
66									
	N/A	24	1.9					Note: Olive gray, 40% coarse sand, subangular, wet @ 67'	
68									
	N/A	24	1.4						
70								Note: Gravel, fine-coarse @ 70' Water sample 70-75' @ 1348	
	N/A	24	0.7						
72									
	N/A	24	1.7				GW	GRAVEL WITH SAND Gray, well graded, fine-medium subrounded-rounded, 25% medium-coarse sand, subrounded-subangular, wet	
74							SW	SAND WITH GRAVEL Olive gray, well graded, medium coarse, subangular, 40% fine gravel, wet	
							GW	GRAVEL WITH SAND Olive gray, well graded, fine medium, subrounded with 30% medium coarse sand, subangular, wet	
	N/A	24	2.9				SW		

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: T. Fortner   Begin Drilling: 3/27/2007

Driller: Gerald Sealey   Total Depth: 121   End Drilling: 3/27/2007

Drilling Method: Rotosonic   Surface Elev.: 732.644   Converted to Well: Y   Well I.D.: GM-67D

Drilling Fluid: Water   North Coor.: 4744.47186   East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010   Datum: TOC: 732.188   Filename: April 2007

Log of Boring: GM-67D

General Motors Corporation
Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
76								SAND Olive gray, well graded medium coarse, subangular with 15% fine subrounded gravel, wet	
	N/A	24	6.3				SC	CLAYEY SAND 10% medium, subrounded, well graded, fine, clay is soft, high plasticity, wet	
							SW	SAND Olive gray, well graded, medium-coarse subangular, 10% fine subrounded gravel, wet	
78									
	N/A	24	8.0						
80									
	N/A	24	1.5						
82									
	N/A	24	0.4				SM	SILTY SAND Olive gray, fine, poorly graded, wet	
								SILTY SAND Olive gray, medium coarse well graded, subangular with 30% fine-medium subangular gravel, wet	
84									
	N/A	24	0.4						
86									
	N/A	24	0.0				GW	GRAVEL WITH SAND Olive gray, well graded, fine-medium, subangular, with 20% coarse subangular sand, wet	

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: T. Fortner
Begin Drilling: 3/27/2007
Driller: Gerald Sealey
Total Depth: 121
End Drilling: 3/27/2007
Drilling Method: Rotosonic
Surface Elev.: 732.644
Converted to Well: Y Well I.D.: GM-67D
Drilling Fluid: Water
North Coor.: 4744.47186
East Coor.: 6082.03970
Remarks:
Project No.: OH000294.0010
Datum: TOC: 732.188
Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
88									
								Note: Coarse gravel @ 88.5'	
	N/A	24	0.5				SW	SAND WITH GRAVEL Olive gray, well graded, fine-medium, subangular, with 20% coarse subangular sand, wet	
90								Water sample 90-95' @ 1558	
	N/A	24	0.0						
92									
	N/A	24	0.0						
94									
	N/A	24	0.8						
96									
	N/A	24	0.0				GW	GRAVEL WITH SAND Olive gray-gray, well graded, fine-medium, subrounded-subangular, with 20% medium coarse subangular sand, wet	
98									
	N/A	24	0.0						
100									

Composite Sample to Lab　Grab Sample to Lab　Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear　Geologist: T. Fortner　Begin Drilling: 3/27/2007

Driller: Gerald Sealey　Total Depth: 121　End Drilling: 3/27/2007

Drilling Method: Rotosonic　Surface Elev.: 732.644　Converted to Well: Y　Well I.D.: GM-67D

Drilling Fluid: Water　North Coor.: 4744.47186　East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010　Datum: TOC: 732.188　Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0						
102									
	N/A	24	0.0					Note: trace cobbles @ 103'	
104									
	N/A	24	0.0						
106							SW	SAND Olive gray, well graded, medium coarse, subangular, 20% fine medium subrounded gravel, wet	
	N/A	24	0.0						
108									
	N/A	24	0.0						
110									
	N/A	24	0.0						
112									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 3/27/2007

Driller: Gerald Sealey | Total Depth: 121 | End Drilling: 3/27/2007

Drilling Method: Rotosonic | Surface Elev.: 732.644 | Converted to Well: Y Well I.D.: GM-67D

Drilling Fluid: Water | North Coor.: 4744.47186 | East Coor.: 6082.03970

Remarks:

Project No.: OH000294.0010 | Datum: TOC: 732.188 | Filename: April 2007

ARCADIS

Log of Boring: GM-67D

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	0.0						
114									
	N/A	24	0.0				GW	GRAVEL WITH SAND Greenish gray, well graded, fine-medium, subrounded-subangular, 40% medium-coarse subangular sand, wet Water sample 115-120' @ 0833	
116									
	N/A	24	0.0						
118									
	N/A	24	0.0					Note: 10% coarse subangular sand @ 119'	
120							CL	SANDY CLAY Mottled (green, olive, gray, brown) with 20% fine-coarse and fine gravel 20%, stiff, medium plasticity, moist	
								End of boring	
122									
124									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: T. Fortner | Begin Drilling: 3/27/2007

Driller: Gerald Sealey | Total Depth: 121 | End Drilling: 3/27/2007

Drilling Method: Rotosonic | Surface Elev.: 732.644 | Converted to Well: Y Well I.D.: GM-67D

Drilling Fluid: Water | North Coor.: 4744.47186 | East Coor.: 6082.03970

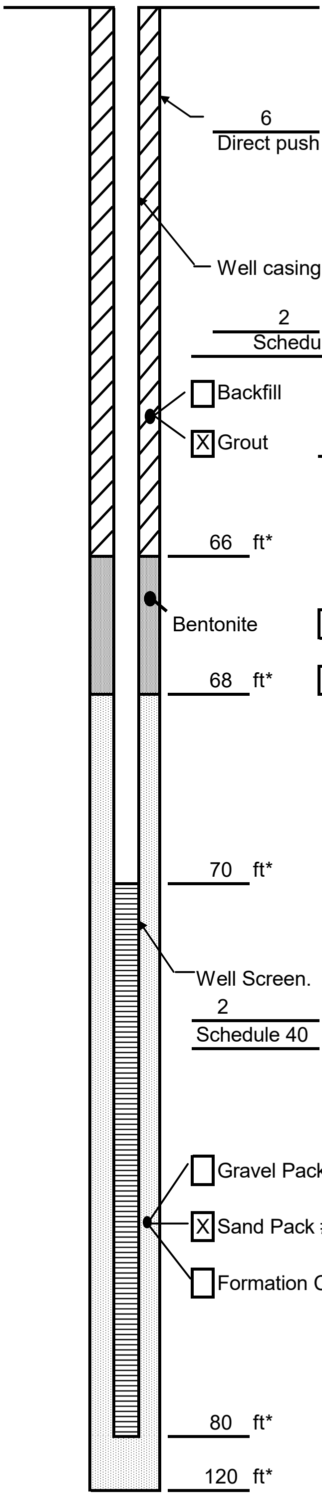
Remarks:

Project No.: OH000294.0010 | Datum: TOC: 732.188 | Filename: April 2007

ARCADIS

Well Construction Log

(Unconsolidated)



6 inch diameter
Direct push hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill

☒ Grout Bentonite/cement

66 ft*

Bentonite ☐ slurry

68 ft* ☒ pellets

70 ft*

Well Screen.
2 inch diameter
Schedule 40, 10 slot

☐ Gravel Pack

☒ Sand Pack #5

☐ Formation Collapse

80 ft*

120 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project: General Motors Corporation Well: GM-67D

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: N/A

Land-Surface (LS) Elevation and Datum:

732.644 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 4/4/2007

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water-removed during vertical aquifer profiling

Development Technique(s) and Date(s)

Submersible pump - surge with pump 4/13/07 by Paul Smith

Fluid Loss During installation 50 gallons

Water Removed During Development 135 gallons

Static Depth to Water 21.4 feet below M.P.

Pumping Depth to Water 77 feet below M.P.

Pumping Duration 0.30 hours

Yield 3 gpm Date 4/11/07

Specific Capacity NM gpm/ft

Well Purpose: GW Monitoring

Note: formation collapse (120' to 80')
Permanent 6" casing set at RCT

Remarks Time: 1330

pH: 7.48

Conductivity: 1.27

Turbidity: 237

Temperature: 14.1

Well purged dry

Prepared by L. Greene

ARCADIS

Log of Boring: GM-67S

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
50								See boring log GM-67D for lithologic description	
52									
54								End of boring	
56									
58									
60									
62									

☒ Composite Sample to Lab ■ Grab Sample to Lab ▯ Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: L. Greene
Begin Drilling: 4/4/2007
Driller: Gerald Sealey
Total Depth: 54
End Drilling: 4/4/2007
Drilling Method: Rotosonic
Surface Elev.: 732.541
Converted to Well: Y Well I.D.: GM-67S
Drilling Fluid: Water
North Coor.: 4744.20516
East Coor.: 6096.21832
Remarks:
Project No.: OH000294.0010
Datum: TOC: 732.062
Filename: April 2007

ARCADIS

Well Construction Log
(Unconsolidated)

Project: General Motors Corporation Well: GM-67S

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: N/A

Land-Surface (LS) Elevation and Datum:

732.541 feet [x] Surveyed [ ] Estimated

Installation Date(s): 4/4/2007

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water-removed during vertical aquifer profiling 50 gallons used during installation of well

Development Technique(s) and Date(s)

Submersible pump - surge with pump

Fluid Loss During installation: 50 gallons

Water Removed During Development: 108 gallons

Static Depth to Water: 20.9 feet below M.P.

Pumping Depth to Water: 51 feet below M.P.

Pumping Duration: 0.6 hours

Yield: 3 gpm Date: 4/12/07

Specific Capacity: NM gpm/ft

Well Purpose: GW Monitoring

Remarks: Time: 0840, 0843, 0846, 0849, 0852, 0855

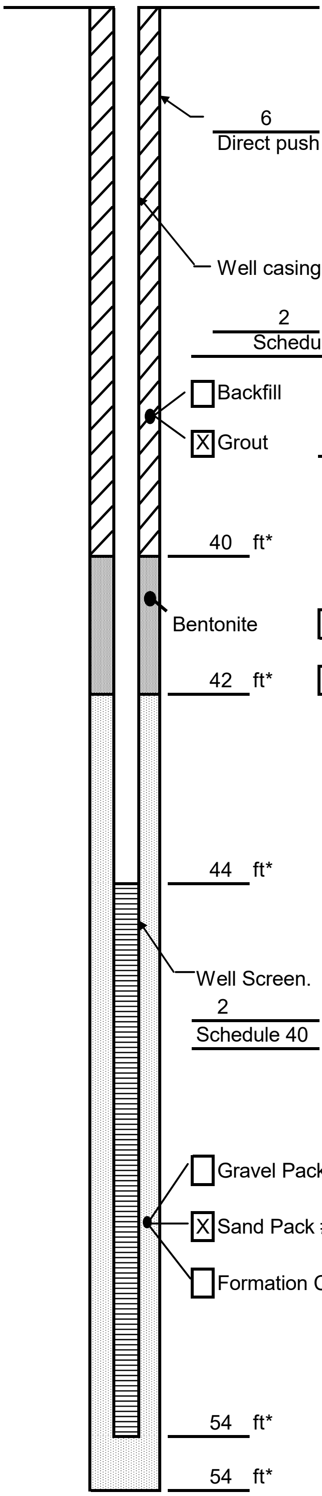
pH: 7.45, 7.72, 7.82, 7.83, 7.84, 7.80

Conductivity: 1.45, 1.45, 1.43, 1.44, 1.44, 1.43

Turbidity: 400, 335, 326, 107, 107, 19

Temperature: 14.5, 14.9, 15.0, 15.0, 15.0, 15.0

Prepared by: L. Greene



6 inch diameter
Direct push hole

Well casing,
2 inch diameter,
Schedule 40 PVC

[ ] Backfill
[X] Grout Bentonite/cement

40 ft*

Bentonite [ ] slurry
42 ft* [X] pellets

44 ft*

Well Screen.
2 inch diameter
Schedule 40, 10 slot

[ ] Gravel Pack
[X] Sand Pack #5
[ ] Formation Collapse

54 ft*

54 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

ARCADIS

Log of Boring: GM-71

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
0	N/A	24	NM					CONCRETE	
							FILL	FILL Sand and gravel, fill	
10	N/A	24	10.4				SP	SAND Dark yellowish brown (10 yr 4/4), poorly graded, medium, 30% gravel (subround), dry	
12	N/A	24	5.9						

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: L. Greene
Begin Drilling: 4/16/2007
Driller: Chris
Total Depth: 36
End Drilling: 4/16/2007
Drilling Method: Rotosonic
Surface Elev.: 737.194
Converted to Well: Y Well I.D.: GM-71
Drilling Fluid: Water
North Coor.: 4493.83914
East Coor.: 6849.32868
Remarks: Water sample 26-31' @ 1020
Project No.: OH000294.0010
Datum: TOC: 736.817
Filename: April 2007

ARCADIS

Log of Boring: GM-71

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
14	N/A	24	3.8						
16	N/A	24	8.6						
18	N/A	24	5.0				SW	SAND Yellowish brown (10 yr 5/4), well graded, fine-coarse, 20% gravel/cobbles (angular-subround), dry	
20	N/A	24	21.0						
22	N/A	24	8.1						
24	N/A	24	5.4						

Composite Sample to Lab   Grab Sample to Lab   Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear   Geologist: L. Greene   Begin Drilling: 4/16/2007

Driller: Chris   Total Depth: 36   End Drilling: 4/16/2007

Drilling Method: Rotosonic   Surface Elev.: 737.194   Converted to Well: Y Well I.D.: GM-71

Drilling Fluid: Water   North Coor.: 4493.83914   East Coor.: 6849.32868

Remarks: Water sample 26-31' @ 1020

Project No.: OH000294.0010   Datum: TOC: 736.817   Filename: April 2007

ARCADIS

Log of Boring: GM-71

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
26	N/A	24	1.5						
28	N/A	24	8.0				SP	GRAVEL WITH SAND Brown (10 yr 5/3), poorly graded, fine medium gravel, (subround-subangular), 10% sand, wet	▼
30	N/A	24	1.7				CL	SILTY CLAY Grayish brown (10 yr 5/2), 5% gravel (angular-subround), dry	
32	N/A	24	2.2						
34	N/A	24	0.9						
36								End of boring	

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: L. Greene | Begin Drilling: 4/16/2007

Driller: Chris | Total Depth: 36 | End Drilling: 4/16/2007

Drilling Method: Rotosonic | Surface Elev.: 737.194 | Converted to Well: Y Well I.D.: GM-71

Drilling Fluid: Water | North Coor.: 4493.83914 | East Coor.: 6849.32868

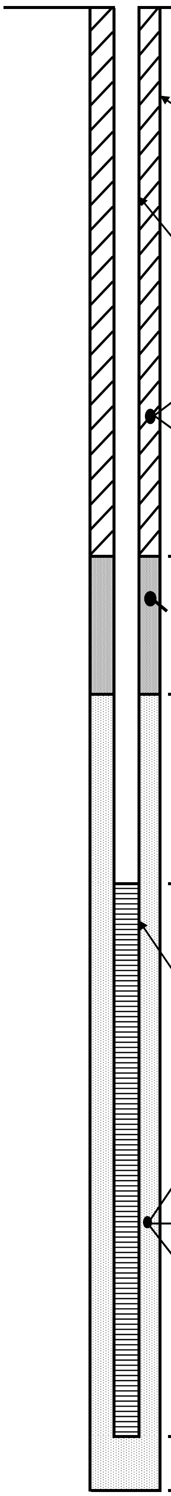
Remarks: Water sample 26-31' @ 1020

Project No.: OH000294.0010 | Datum: TOC: 736.817 | Filename: April 2007

ARCADIS

Well Construction Log

(Unconsolidated)



6 inch diameter
Direct push hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Bentonite/cement

17 ft*

Bentonite ☐ slurry
19 ft* ☒ pellets

21 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

31 ft*

37 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project: General Motors Corporation Well: GM-71

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: N/A

Land-Surface (LS) Elevation and Datum:

737.194 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 4/20/2007

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump, surge with pump

4/26/07 Jim Wallace

Fluid Loss During Drilling 200 gallons

Water Removed During Development 60 gallons

Static Depth to Water 25.62 feet below M.P.

Pumping Depth to Water NM feet below M.P.

Pumping Duration 1 hours

Yield 1 gpm Date 4/26/07

Specific Capacity NM gpm/ft

Well Purpose: Monitoring well

Remarks Time: 1125, 1130, 1135, 1140, 1145

pH: 6.81, 6.80, 6.74, 6.78, 6.80

Conductivity: 2.21, 214, 2.12, 2.12, 2.12

Turbidity: 58, 17, 10, 6, 10

Temperature: 17.2, 17.9, 17.8, 17.8, 17.7

Prepared by L. Greene

ARCADIS

Log of Boring: GM-72

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
								0-30 feet see boring log GM-71 for lithologic description	
30	N/A	24	2.3				CL	CLAY Light brown (10 yr 5/7), hard, 10% gravel, dry	
32	N/A	24	4.7					Note: Olive gray (10 yr 5/1) @ 32'	
34	N/A	24	3.1						
36	N/A	24	5.9						
							SW	SAND WITH GRAVEL Light brown (10 yr 6/4), medium-coarse, with 40% gravel (gravel up to 2"), loose, wet	
38	N/A	24	6.2						
40	N/A	24	5.4						

Composite Sample to Lab Grab Sample to Lab Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: J. Wallace
Begin Drilling: 4/24/2007
Driller: Chris
Total Depth: 68
End Drilling: 4/24/2007
Drilling Method: Rotosonic
Surface Elev.: 737.050
Converted to Well: Y Well I.D.: GM-72
Drilling Fluid: Water
North Coor.: 4496.04384
East Coor.: 6860.84485
Remarks: Water sample 42-47' @ 0930; 57-62' @ 1325
Project No.: OH000294.0010
Datum: TOC: 736.778
Filename: April 2007

Log of Boring: GM-72

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
42	N/A	24	5.9						
44	N/A	24	7.0						
46	N/A	24	3.6				GW	GRAVEL WITH SAND Light brown, loose, gravel up to 3", 20% sand, wet	
48	N/A	24	6.6				GP	GRAVEL Light brown to gray (10 yr 6/4), poorly graded, fine to medium gravel, loose, well rounded, with 10% sand, wet	
50	N/A	24	2.6					Note: Gravel up 1", 10% sand @ 50'	
52	N/A	24	5.1					Note: No gravel larger than 0.5" @ 52'	
54									

Composite Sample to Lab | Grab Sample to Lab | Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear | Geologist: J. Wallace | Begin Drilling: 4/24/2007

Driller: Chris | Total Depth: 68 | End Drilling: 4/24/2007

Drilling Method: Rotosonic | Surface Elev.: 737.050 | Converted to Well: Y Well I.D.: GM-72

Drilling Fluid: Water | North Coor.: 4496.04384 | East Coor.: 6860.84485

Remarks: Water sample 42-47' @ 0930; 57-62' @ 1325

Project No.: OH000294.0010 | Datum: TOC: 736.778 | Filename: April 2007

ARCADIS

Log of Boring: GM-72

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
	N/A	24	5.6						
							GW	GRAVEL Light brown (10 yr 6/4) with fine sand, silt and some clay, wet	
56	N/A	24	9.4					Note: No clay @ 56'	
							SP	SAND Light brown (10 yr 4/4), fine to medium sand, loose, <10% gravel, wet	
58	N/A	24	26.4				GW	GRAVEL Light brown with 30% fine to medium sand, loose, wet	
60	N/A	24	7.7				SP	SAND Light brown (10 yr 5/2), medium sand with 30% gravel, loose, wet	
								Note: Fine sand @ 61'	
62	N/A	24	4.7				CL	CLAY Gray (10 yr 4/1), hard, with <10% gravel, dry	
64	N/A	24	4.1						
66	N/A	12	4.1						

☒ Composite Sample to Lab ■ Grab Sample to Lab ▯ Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear
Geologist: J. Wallace
Begin Drilling: 4/24/2007
Driller: Chris
Total Depth: 68
End Drilling: 4/24/2007
Drilling Method: Rotosonic
Surface Elev.: 737.050
Converted to Well: Y Well I.D.: GM-72
Drilling Fluid: Water
North Coor.: 4496.04384
East Coor.: 6860.84485
Remarks: Water sample 42-47' @ 0930; 57-62' @ 1325
Project No.: OH000294.0010
Datum: TOC: 736.778
Filename: April 2007

ARCADIS

Log of Boring: GM-72

General Motors Corporation

Moraine, Ohio

Depth (feet)	Blows (/6 in.)	Recovery (Inches)	OVA (PPM)	Sample Analysis	Sample Type	Graphic Log	Soil Class.	Description	Depth to Water
								End of boring	
68									
70									
72									
74									
76									
78									

Composite Sample to Lab — Grab Sample to Lab — Split-Spoon Not Analyzed

Drilling Co.: Boart Longyear — Geologist: J. Wallace — Begin Drilling: 4/24/2007

Driller: Chris — Total Depth: 68 — End Drilling: 4/24/2007

Drilling Method: Rotosonic — Surface Elev.: 737.050 — Converted to Well: Y Well I.D.: GM-72

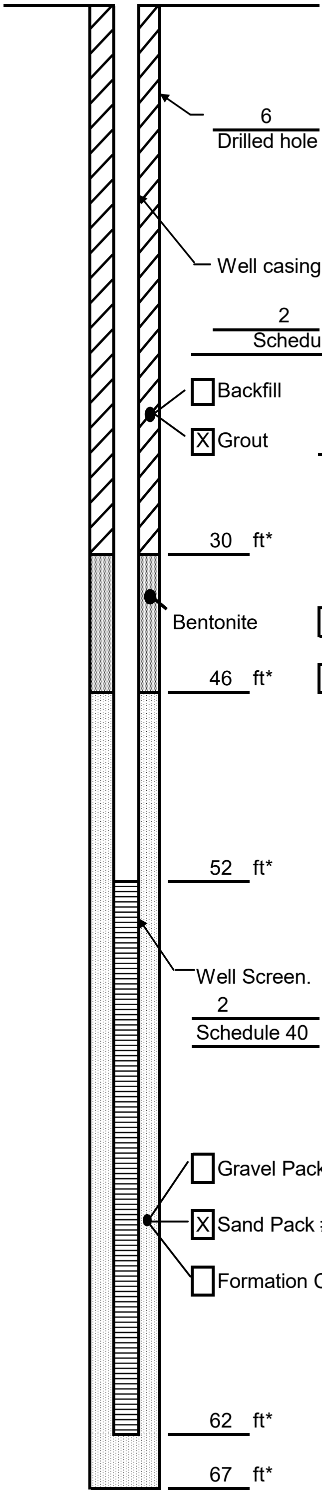
Drilling Fluid: Water — North Coor.: 4496.04384 — East Coor.: 6860.84485

Remarks: Water sample 42-47' @ 0930; 57-62' @ 1325

Project No.: OH000294.0010 — Datum: TOC: 736.778 — Filename: April 2007

ARCADIS

Well Construction Log
(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.

* Depth Below Land Surface

Project: General Motors Corporation Well: GM-72

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: N/A

Land-Surface (LS) Elevation and Datum:

737.050 feet [x] Surveyed [ ] Estimated

Installation Date(s): 4/26/2007

Drilling Method: Sonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Fluid Loss During Drilling: 15 gallons

Water Removed During Development: ______ gallons

Static Depth to Water: ______ feet below M.P.

Pumping Depth to Water: ______ feet below M.P.

Pumping Duration: ______ hours

Yield: ______ gpm Date: ______

Specific Capacity: ______ gpm/ft

Well Purpose: Monitoring well

Remarks

Prepared by: J. Wallace

Soil Boring Log

Project Name: General Motors Corporation
Project Number: OH000294.0010.00002
Project Location: Moraine, Ohio

Date Started: 08/29/2007
Date Completed: 09/17/2007

Logger: L. Greene
Editor: J. Hunt
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
0–4							Utility clearance with water knife (8-27-07). CONCRETE	
4–6			0				Material excavated	
6–8	X		24	GP	>2000		SAND (SP), brownish gray, poorly graded, fine to medium, trace silt; medium dense, dry, cobbles present.	
8–10	X		0	GP			No return.	
10–12	X		0	GP			No return, cobble in tooling shoe.	
12–14	X		12	GP	906		SAND (SP), brown, poorly graded, fine to medium, trace medium gravel, medium dense, dry. (from 13 ft)	
14–15	X							

Drilling Co.: Frontz
Driller: Dave S.
Drilling Method: Direct push/Rotosonic
Drilling Fluid: Water
Remarks: Permanent casing (10 inch) installed to 30.5 feet.
GP=Geoprobe
SD=Sonic Drilling

Sampling Method: 10 feet x 4 inch Core Barrel
Sampling Interval: 10 feet
Water Level Start: 26 feet
Water Level Finish: --
Converted to Well: [X] Yes [ ] No
Surface Elev.: 732.5
North Coor: 4203.3
East Coor: 6417.2

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Project Name: General Motors Corporation | Date Started: 08/29/2007 | Logger: L. Greene

Project Number: OH000294.0010.00002 | Date Completed: 09/17/2007 | Editor: J. Hunt

Project Location: Moraine, Ohio | Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
15–16			24	GP	570	SP	SAND (SP), brown, poorly graded, fine to medium, trace medium gravel, medium dense, dry.	
16–18			6	GP	1024		No return.	
18–20			24	GP	1201	SP	SAND (SP), brown, poorly graded, fine to medium, trace medium gravel, dense, dry. Note: broken up cobbles.	
20–22			3	GP	473			
22–24			24	GP	512	SW	SAND (SW), grayish brown, well graded, fine to coarse, trace silt, medium dense, dry; silt is oxidized.	
24–26			12	GP	37.0	SW	SAND (SW), grayish brown, well graded, fine to coarse, trace silt, medium dense, dry; wet at 26 feet; silt is oxidized.	
26–28			24		269	SW	SAND (SW), grayish brown, well graded, fine to coarse, trace silt, medium dense, dry silt is oxidized.	
28–30			24	GM-74, 26 to 31 feet, 8/29/07, 17:30 GP	0.0	ML	SILT (ML), dark gray, very stiff, hard, trace angular gravel, trace clay, dry.	
30–31			12	GP	0.0			

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Project Name:	General Motors Corporation	Date Started:	08/29/2007
Logger:	L. Greene		
Project Number:	OH000294.0010.00002	Date Completed:	09/17/2007
Editor:	J. Hunt		
Project Location:	Moraine, Ohio	Weather Conditions:	Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
31–35			12		0.0	ML	CLAYEY SILT (ML), dark gray, very stiff to hard, low plasticity, trace angular gravel, dry.	
			24		0.3			
35–40				SD		SW	SAND (SW), orangish brown, well graded, fine to coarse, little gravel, loose, damp.	
			24		0.5			
			24		1.6			
40–46			24		0.0	GW	SANDY GRAVEL (GW), gray, well graded, fine to coarse, loose, wet.	
			24		0.0			
			24		0.0			
46–47			24		0.7	SW	SAND (SW), brown, well graded, fine to coarse, medium loose, trace subrounded gravel, wet.	

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 09/17/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
48			24	GM-74, 45 to 50 feet, (9/17/07, 14:34	1.7		SAND (SW), brown, well graded, fine to coarse, medium loose, trace subrounded gravel, wet.	
50			24		0.0		SILTY SAND (SW), orangish brown, well graded, trace clay, cohesive, very stiff to hard, dry.	
51							CLAYEY SILT (ML), dark gray, very stiff, no plasticity, trace angular gravel, trace sand, dry.	
52			24		0.0			
54			24		0.0			
55				SD			3 inch silt seam at 55 feet.	
56			24		0.0		SILT (ML), gray, cohesive, trace clay, medium stiff, dry.	
58			24		0.0		CLAYEY SILT (ML), dark gray, very stiff, no plasticity, trace angular gravel, trace sand, dry.	
60			24		0.0		CLAYEY SILT (ML), dark gray, very stiff hard, very low plasticity, trace angular gravel, trace sand, and organic material, dry.	
62			24		0.0			
63								

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 09/17/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
64						ML	CLAYEY SILT (ML), dark gray, very stiff hard, very low plasticity, trace angular gravel, trace sand, and organic material, dry.	
65				SD			Wood at 65 feet (6 inches)..	
66			24		2.0			
67						SW	SAND (SW), orangish brown, well graded, fine to coarse, some gravel (subround), loose, wet.	
68			24		1.8			
69								
70			24		0.0			
71								
72			24		0.0			
73								
74			24		0.0			
75				SD				
76			24		0.0			
77						SW	SAND (SW), orangish brown, poorly graded, fine to medium grained, cohesive, medium loose, damp.	
78			24		0.0			
79						ML	SILT (ML), gray, medium soft, dry.	

Remarks:

ARCADIS

Soil Boring Log

Project Name: General Motors Corporation | Date Started: 08/29/2007 | Logger: L. Greene

Project Number: OH000294.0010.00002 | Date Completed: 09/17/2007 | Editor: J. Hunt

Project Location: Moraine, Ohio | Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
80						ML	SILT (ML), gray, medium soft, dry.	
80–81			24		1.7	SP	SAND (SP), gray, poorly graded, fine grained, trace silt, medium loose, wet.	
82			24		8.2			
83						ML	SILT (ML), gray, medium soft to stiff, dry.	
84			24		12.6	SW	SAND (SW), dark gray, well graded, fine to coarse, trace silt, loose, wet.	
85				SD				
86			24		13.8			
88			24		6.1		Note: Some subrounded gravel at 88 feet.	
90			24		2.0		Note: trace small cobbles.	
92			24		1.7			
93						SW	SAND (SW), brownish gray, well graded, fine to coarse, trace gravel, loose, wet.	
94			24		0.5			
95				SD				

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Project Name: General Motors Corporation | Date Started: 08/29/2007 | Logger: L. Greene

Project Number: OH000294.0010.00002 | Date Completed: 09/17/2007 | Editor: J. Hunt

Project Location: Moraine, Ohio | Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
96			24		1.1		SAND (SW), brownish gray, well graded, fine to coarse, trace gravel, loose, wet.	
97								
98			24		1.4			
99								
100			24		1.0		Note: trace small cobbles and some gravel.	
101								
102			24		0.0			
103								
104			24		0.0			
105				SD				
106			24		0.0			
107								
108			24		0.1			
109								
110			24		0.0		SAND (SW), dark gray, well graded, fine to medium, trace gravel, medium loose, wet.	
111								

Remarks:

SOIL BORING LOG BORING LOG.GPJ ARCADIS.GDT 2/13/08

ARCADIS

Soil Boring Log

Boring No.: GM-74D

Sheet: 8 of 8

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 09/17/2007
Editor: J. Hunt

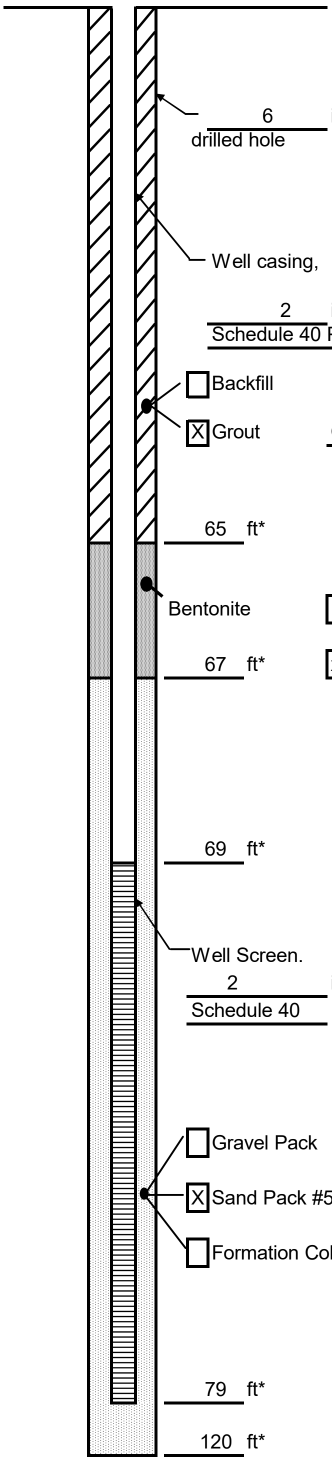
Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
112			24		0.7		SANDY GRAVEL (SW), gray, fine to coarse, well graded, loose, wet.	
113								
114			24		0.5			
115				SD			CLAYEY SAND (SW), brown, well graded, little gravel, fine to coarse, cohesive, medium loose to dense, wet.	
116			24		0.0			
117								
118			24		0.0			
119								
120								
121								
122								
123								
124								
125								
126								
127								

Remarks:

ARCADIS

Well Construction Log
(Unconsolidated)



6 inch diameter drilled hole

Well casing, 2 inch diameter, Schedule 40 PVC

☐ Backfill
☒ Grout Cement

65 ft*

Bentonite ☐ slurry
67 ft* ☒ pellets

69 ft*

Well Screen. 2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

79 ft*
120 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-74D

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

732.49 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 9/21/2007

Drilling Method: Rotosonic

Drilling Contractor: Frontz Driling

Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump & surge - 9/24/2007.

Fluid Loss During Drilling ______ gallons

Water Removed During Development ______ gallons

Static Depth to Water ______ feet below M.P.

Pumping Depth to Water ______ feet below M.P.

Pumping Duration ______ hours

Yield ______ gpm Date ______

Specific Capacity ______ gpm/ft

Well Purpose: Monitoring Well

Remarks: 8" permanent casing to 30.5 feet north well at GM-74 location

Prepared by: L. Greene

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ARCADIS

Soil Boring Log

Boring No.: GM-74S

Sheet: 1 of 1

Project Name: General Motors Corporation
Date Started: 09/21/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 09/21/2007
Editor: J.Hunt

Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description
1							See boring log GM-74D for lithologic description.
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
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36							
37							
38							
39							
40							
41							
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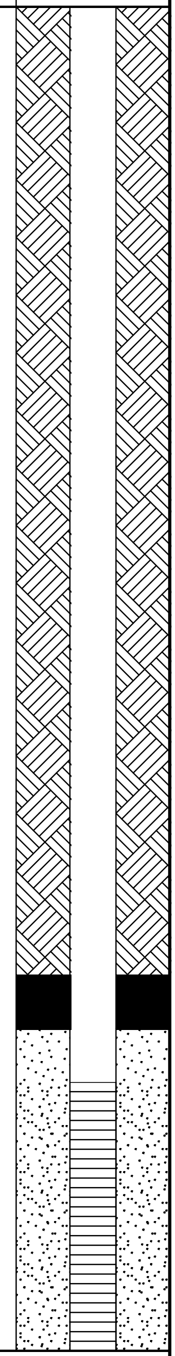
43							
44							
45							
46							
47							
48							
49							
50							

Construction Details

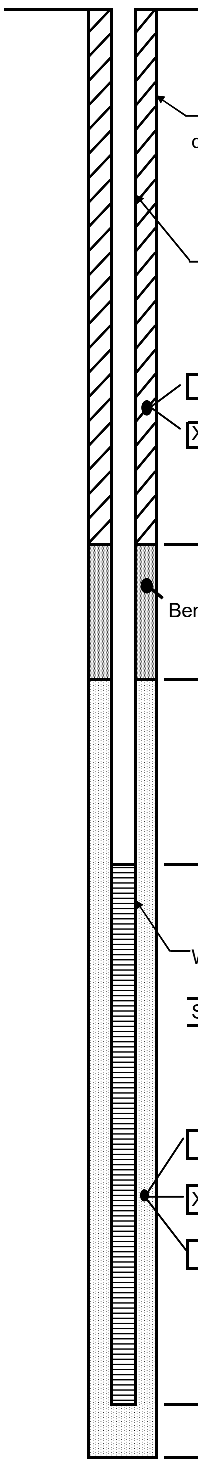


Drilling Co.: Frontz
Driller: Dave S.
Drilling Method: Rotosonic
Drilling Fluid: Water
Remarks:

Sampling Method: Core Barrel
Sampling Interval: 10 feet
Water Level Start: NA
Water Level Finish: NA
Converted to Well: ☒ Yes ☐ No
Surface Elev.: 732.52 TOC=732.17
North Coor: 4197.6
East Coor: 6416.5

ARCADIS

Well Construction Log
(Unconsolidated)



6 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement

36 ft*

Bentonite ☐ slurry

38 ft* ☒ pellets

40 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot PVC

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

50 ft*

50 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-74S

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

732.52 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 9/21/2007

Drilling Method: Rotosonic

Drilling Contractor: Frontz Driling

Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump & surge - 9/24/2007. All drilling fluid removed during VAS.

Fluid Loss During Drilling: N/A gallons

Water Removed During Development: 60 gallons

Static Depth to Water: 25.01 feet below M.P.

Pumping Depth to Water: 45 feet below M.P.

Pumping Duration: 0.30 hours

Yield: 3 gpm Date: 9/24/07

Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well

Remarks: South well @ GM-74 location

Time:16:20, 16:23, 16:26, 16:29

pH: 6.66, 6.65, 6.62, 6.60

Conductivity: 2.17, 1.99, 2.01, 1.94

Turbidity: 78, 64, 60, 62

Temperature: 22.3, 22.6, 22.4, 22.0

Prepared by: L. Greene

ARCADIS

Soil Boring Log

Boring No.: GM-75D

Sheet: 1 of 8

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 09/12/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
0–3							Utility clearing with water knife (8-27-07). CONCRETE	
3–11							Material excavated	
10–12	X		12	GP	2000			
11–12							SAND (SP), dark brown, poorly graded, fine to medium, trace silt and clay, medium dense, dry.	
12–14	X		10	GP			No return.	
14–15	X							

Drilling Co.: Frontz
Driller: Dave S.
Drilling Method: Direct push/Rotosonic
Drilling Fluid: Water
Remarks: GP=Geoprobe
SD=Sonic Drilling

Sampling Method: 10 feet x 4 inch Core Barrel
Sampling Interval: 10 feet
Water Level Start: 31.5 feet
Water Level Finish: --
Converted to Well: [X] Yes [ ] No
Surface Elev.: 738.13 TOC=737.68
North Coor: 4604.3
East Coor: 6622.7

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 09/12/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
15-16			12	GP	1150		GRAVELLY SAND (SP), brownish gray, poorly graded, medium to coarse, medium loose, 30% gravel (subangular to subrounded), dry.	
16-18			0	GP			No return.	
18-20			24	GP	364		GRAVELLY SAND (SP), brownish gray, poorly graded, medium to coarse, medium loose, 30% gravel (subangular to subrounded), dry at 19.5 feet trace of silt, yellowish brown.	
20-22			0	GP			No return.	
22-24			24	GP	>2000		GRAVELLY SAND (SP), brownish gray, poorly graded, medium to coarse, medium loose, 30% gravel (subangular to subrounded), dry.	
24-26			0	GP			No return.	
26-28			24	GP	>2000		SAND (SP), with gravel, dark yellowish brown, poorly graded, fine to coarse, 15% gravel, medium loose, dry.	
28-30			0	GP			No return.	
30-31				GP				

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-75D

Sheet: 3 of 8

Project Name: General Motors Corporation | Date Started: 08/29/2007 | Logger: L. Greene

Project Number: OH000294.0010.00002 | Date Completed: 09/12/2007 | Editor: J. Hunt

Project Location: Moraine, Ohio | Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
31–32			18		1043	SP	SAND (SP), dark yellowish brown, fine to coarse, 5% to 10% gravel, poorly graded, medium loose, dry, wet at 31.5 feet.	
32–34			0	GP			No return.	
34–36			15		>2000	SW	SAND (SW), grayish brown well graded, fine to coarse, some gravel (10%), medium loose, wet.	
36–38			0	GP GM-75, 35 to 40 feet, 8/29/07, 14:00			No return.	
38–40			12	GP	155	SW	SAND (SW), grayish brown well graded, fine to coarse, some gravel (10%), medium loose, wet.	
40–42			24		1.0	SW	GRAVELLY SAND (SW), brownish gray, well graded, trace cobbles, medium coarse, loose, wet.	
42			24		0.7			
44			24		0.3			
45				SD				
46			24		0.2		Note: Trace of silt at 46 feet.	
47								

Remarks:

ARCADIS

Soil Boring Log

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 09/12/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
47–48							SAND (SW), brownish gray, well graded, trace cobbles, medium to coarse, loose, wet.	
48			24		1.1		GRAVELLY SAND (SW), brownish gray well graded, trace cobbles, medium to coarse, loose, wet.	
50			24		0.8			
52			24		0.0		SILT (ML), dark gray, trace gravel, stiff to very stiff, dry (till), trace clay.	
54			24		0.1			
55							SILT (ML), dark gray, black mottling (organic), medium loose to medium dense, dry.	
56			24		0.6		SAND (SP), brown, poorly graded, fine to coarse, medium loose, wet.	
58			24	GM-75, 56 to 61 feet, 9/14/07, 12:00	1.1			
60			24		0.0		Note: Brownish gray and damp at 60 feet.	
62			24		0.0			

Remarks:

Soil Boring Log

Boring No.: GM-75D

Project Name: General Motors Corporation — Date Started: 08/29/2007 — Logger: L. Greene

Project Number: OH000294.0010.00002 — Date Completed: 09/12/2007 — Editor: J. Hunt

Project Location: Moraine, Ohio — Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
64			24		0.0	ML	CLAYEY SILT (ML), dark gray, very stiff; hard, trace gravel and sand, dry.	
65				SD				
66			24		0.0			
67								
68			24		1.7			
69						SW	GRAVELLY SAND (SW), yellowish brown, well graded, fine to coarse, loose, wet.	
70			24		0.0			
71								
72			24		0.0			
73								
74			24		0.0			
75				SD				
76			24		0.0			
77								
78			24		0.3			
79						SW	SAND (SW), brownish gray, well graded, (20% gravel), medium loose, wet.	

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-75D

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 09/12/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
79–80						SW	SAND (SW), brownish gray, well graded, (20% gravel), medium loose, wet.	
80			24		39.7	SW	SAND (SW), brown, poorly graded, fine to medium, medium loose, damp.	
82			24		59.2		Note: Brownish gray, and oxidation at 82 feet.	
84			24		5.6	SW	SILTY SAND (SW), gray, fine grained, medium loose to medium dense, damp.	
85				SD				
86			24		11.6		Note: Clayey silt seam at 86 feet (3 inches).	
87						SP	SAND (SP), brownish gray, poorly graded, medium loose, damp.	
88			24		1.1	SW	SAND (SW), brownish gray, well graded, fine to coarse, trace clay and gravel, dense, damp.	
89						SW	GRAVELLY SAND (SW), brownish gray, fine to coarse, loose, wet.	
90			24		1.0	GW	SANDY GRAVEL (GW), gray, well graded, fine to coarse, loose, wet.	
92			24		2.7			
94			24		3.4			
95				SD				

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-75D

Sheet: 7 of 8

Project Name: General Motors Corporation
Date Started: 08/29/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 09/12/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
96			24		3.0		SANDY GRAVEL (GW), gray, well graded, fine to coarse, loose, wet.	
97								
98			24		1.2			
99								
100			24		0.0		Note: cobbles present at 100 feet.	
101								
102			24		0.9			
103								
104			24		0.0			
105				SD				
106			24		0.0			
107								
108			24		0.0			
109								
110			24		0.0			
111								

Remarks:

ARCADIS

Soil Boring Log

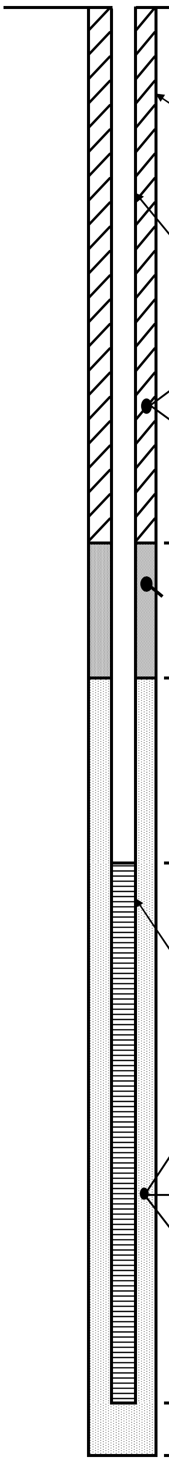
Project Name: General Motors Corporation
Project Number: OH000294.0010.00002
Project Location: Moraine, Ohio
Date Started: 08/29/2007
Date Completed: 09/12/2007
Logger: L. Greene
Editor: J. Hunt
Weather Conditions: Sunny 70's

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
112			24		0.7		SAND (SW), gray, well graded, fine to coarse, trace gravel, medium loose, wet.	
113								
114			24		1.0		SAND (SW), grayish brown, poorly graded, fine grained, medium loose, damp.	
115				SD				
116			24		0.3			
117								
118			24		0.0		Note: Trace large gravel at 118 feet.	
119								
120								
121								
122								
123								
124								
125								
126								
127								

Remarks:

ARCADIS

Well Construction Log
(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

- Project: General Motors Corporation — Well: GM-75D
- Town/City: Moraine
- County: Montgomery — State: Ohio
- Permit No.: NA
- Land-Surface (LS) Elevation and Datum: 738.13 feet — ☒ Surveyed ☐ Estimated
- Installation Date(s): 9/20/2007
- Drilling Method: Rotosonic
- Drilling Contractor: Frontz Driling
- Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump & surge - 9/25/2007. All drilling fluid removed during VAS.

- Fluid Loss During Drilling: N/A gallons
- Water Removed During Development: 60 gallons
- Static Depth to Water: 30.53 feet below M.P.
- Pumping Depth to Water: 90 feet below M.P.
- Pumping Duration: 0.30 hours
- Yield: 3 gpm — Date: 9/25/07
- Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well

Remarks: West well at GM-75 location

Time: 11:30, 11:33, 11:36, 11:39

pH: 6.34, 6.34, 6.31, 6.33

Conductivity: 1.70, 1.80, 1.77, 1.79

Turbidity: 338, 210, 10, 198

Temperature: 18.7, 18.7, 18.7, 18.5

Prepared by: L. Greene

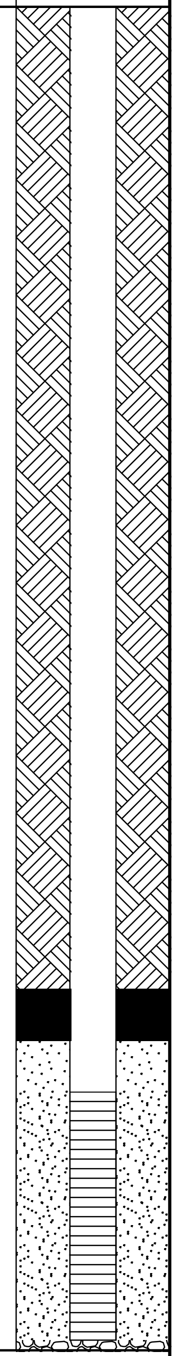
ARCADIS

Soil Boring Log

Boring No.: GM-75S

Sheet: 1 of 1

Project Name:	General Motors Corporation	Date Started: 09/18/2007	Logger: L. Greene
Project Number:	OH000294.0010.00002	Date Completed: 09/18/2007	Editor: J. Hunt
Project Location:	Moraine, Ohio		Weather Conditions: Sunny 70's

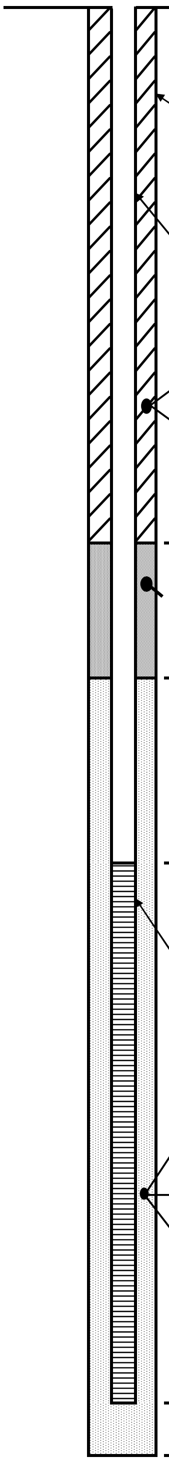
Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
1–52							See boring log GM-75D for lithologic description.	

Drilling Co.:	Frontz	Sampling Method:	Core Barrel
Driller:	Dave S.	Sampling Interval:	10 feet
Drilling Method:	Rotosonic	Water Level Start:	NA
Drilling Fluid:	Water	Water Level Finish:	NA
Remarks:		Converted to Well:	☒ Yes ☐ No
		Surface Elev.:	738.26 TOC=737.69
		North Coor:	4604.6
		East Coor:	6634.7

ARCADIS

Well Construction Log

(Unconsolidated)



6 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement

38 ft*

Bentonite ☐ slurry
40 ft* ☒ pellets

42 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

51.6 ft*

52 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-75S

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

738.26 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 9/18/2007

Drilling Method: Rotosonic

Drilling Contractor: Frontz Driling

Drilling Fluid: Water

Development Technique(s) and Date(s)

Submersible pump & surge - 9/25/2007. All drilling fluid removed during VAS.

Fluid Loss During Drilling: NA gallons

Water Removed During Development: 60 gallons

Static Depth to Water: 30.44 feet below M.P.

Pumping Depth to Water: 47 feet below M.P.

Pumping Duration: 0.30 hours

Yield: 3 gpm Date: 9/25/07

Specific Capacity: NM gpm/ft

Well Purpose: Monitoring Well

Remarks: East well @ GM-75 location

Time: 10:50, 10:53, 10:56, 10:59

pH: 6.52, 6.57, 6.50, 6.51

Conductivity: 1.45, 1.39, 1.37, 1.36

Turbidity: 435, 222, 113, 87

Temperature: 20.2, 20.1, 19.8, 19.8

Prepared by: L. Greene

ARCADIS

Soil Boring Log

Boring No.: GM-76D

Sheet: 1 of 8

Project Name:	General Motors Corporation	Date Started:	07/06/2007	Logger:	L. Greene
Project Number:	OH000294.0010.00002	Date Completed:	07/09/2007	Editor:	J. Hunt
Project Location:	Moraine, Ohio			Weather Conditions:	Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
0–1							CONCRETE	
1–10							SAND WITH GRAVEL (SP), brown, poorly graded, medium-coarse, 25-30% gravel (subrounded), fine-coarse, dry.	
10–15	10–15		24		0.3		SAND WITH GRAVEL (SP), dark brown, poorly graded, fine-coarse, 15% gravel (subrounded), medium-loose, dry.	
12			24		2.5			
14			24		11.9			

Drilling Co.:	Boart Longyear	Sampling Method:	Core Barrel
Driller:	Walter Tidwell	Sampling Interval:	10 feet
Drilling Method:	Rotosonic	Water Level Start:	34 feet
Drilling Fluid:	Water	Water Level Finish:	--
Remarks:	Non-invasive water knife/vac used to elevation to 10 feet.	Converted to Well:	☒ Yes ☐ No
	SD=Sonic Drilling	Surface Elev.:	739.48 TOC=738.94
		North Coor:	5391.8
		East Coor:	6729.9

ARCADIS

Soil Boring Log

Boring No.: GM-76D

Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
15–20			24	SD	10.0	SP	SAND WITH GRAVEL (SP), dark brown, poorly graded, fine-coarse, 15% gravel (subrounded), medium-loose, dry. Note: pale brown (10 YR 6/3) at 17 feet.	
			12		5.1			
19–26							No return.	
20–30				SD				
26–30			24		6.0	SP	SAND (SP), pale brown (10 YR 6/3), poorly graded, fine-coarse, trace gravel, medium-loose, dry.	
			24		2.5			
30–31			24		1.5	SP	CLAYEY SAND (SP), grayish brown, poorly graded (10 YR 5/2), low plasticity, fine-medium grained, 20% clay, medium-soft, moist.	

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-76D

Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
31–32							CLAYEY SAND (SP), grayish brown, poorly graded (10 YR 5/2), low plasticity, fine-medium grained, 20% clay, medium-soft, moist.	
32			24		0.8		SAND (SP), dark gray (10 YR 4/1), poorly graded, trace clay and gravel, damp.	
34			24	GM-76, 32 to 36 feet, 7/6/07, 12:33	0.7		SAND AND GRAVEL (GW), gray (10 YR 5/1), well graded, fine-medium, 15% coarse sand, wet.	
36			24		0.7		SILTY SAND (SP), brown (10 YR 5/3), poorly graded, fine, cohesive, slight dense, moist.	
38			24		0.6		SAND (SP), dark gray 910 YR 4/1), poorly graded, trace clay and gravel, damp.	
39							CLAYEY SILT (ML), gray (10 YR 5/1), very stiff, trace gravel, low plasticity, dry.	
40			24		8.9			
42			24		3.1			
44			24		0.7			
46			24		1.7			
47								

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-76D

Sheet: 4 of 8

Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
48			12		0.8		CLAYEY SILT (ML), gray (10 YR 5/1), very stiff, trace gravel, low plasticity, dry.	
49							SAND (SP), very dark grayish brown (10 YR 3/2), poorly graded, fine-medium, loose, damp.	
50			24	GM-76, 48 to 52 feet, 7/6/07, 18:45	1.1			
51							CLAYEY SAND (SP), very dark grayish brown (10 YR 3/2), poorly graded, fine, trace gravel, damp.	
52			24		0.2			
53								
54			24		0.7		SILT (ML), very dark grayish brown (10 YR 3/2), trace sand and gravel, stiff-very stiff, dry.	
55				SD				
56			24		1.7		CLAYEY SILT, very dark grayish brown (10 YR 3/2), trace sand and gravel, stiff-very stiff, low plasticity, dry.	
57								
58			24		2.3			
59								
60			24		32			
61								
62			24		50.1			
63								

Remarks:

ARCADIS

Soil Boring Log

Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
64			24		50.8		CLAYEY SILT, very dark grayish brown (10 YR 3/2), trace sand and gravel, stiff-very stiff, low plasticity, dry.	
65				SD				
66			24		48.7			
67								
68			24		35.1			
69								
70			24		13.5		SANDY GRAVEL (GW), grayish brown (10 YR 5/2), well graded, 30% sand, wet.	
71								
72			24	GM-76, 70 to 74 feet, 7/9/07, 08:55	2.6		SAND WITH GRAVEL (SW), grayish brown (10 YR 5/2), well graded, fine-coarse, wet.	
73								
74			24		7.6		GRAVEL (GP), grayish brown (10 YR 5/2), poorly graded, coarse, round-subround, wet.	
75							SAND (SP), grayish brown (10 YR 5/2), poorly graded, fine-medium grained, wet.	
76			24		1.4			
77								
78			24		11.7			
79								

Remarks:

ARCADIS

Soil Boring Log

Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene

Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt

Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
79.5–80						SP	SAND (SP), grayish brown (10 YR 5/2), poorly graded, fine-medium grained, wet.	
80			24		25.9	SP	SILTY SAND (SP), grayish brown (10 YR 5/2), poorly graded, fine, dense, damp.	
82			24		27.9	SP	SAND (SP), grayish brown (10 YR 5/2), poorly graded, fine-medium, medium dense, damp.	
84			24		31.8			
86			24		33.3			
88			24		33.7			
90				GM-76, 88 to 92 feet, 7/9/07, 11:58			No return.	
95				SD				

Remarks:

ARCADIS

Soil Boring Log

Boring No.: GM-76D

Project Name: General Motors Corporation — Date Started: 07/06/2007 — Logger: L. Greene
Project Number: OH000294.0010.00002 — Date Completed: 07/09/2007 — Editor: J. Hunt
Project Location: Moraine, Ohio — Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
95.5–96							No return.	
96			24		1.7	GW	SANDY GRAVEL (GW), gray (10 YR 5/1), well sorted, medium-coarse, wet.	
98			24		0.9			
100							No return.	
105				SD				
106			24		24.8	SW	SAND (SW), dark grayish brown (10 YR 4/2), well sorted, fine-coarse, trace gravel, damp.	
108			24		21.9			
110			24		28.3		Note: Little gravel at 110 feet.	

Remarks:

Soil Boring Log

Boring No.: GM-76D

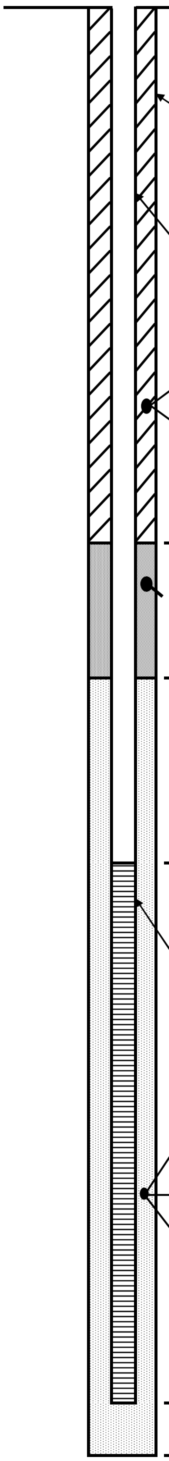
Project Name: General Motors Corporation
Date Started: 07/06/2007
Logger: L. Greene
Project Number: OH000294.0010.00002
Date Completed: 07/09/2007
Editor: J. Hunt
Project Location: Moraine, Ohio
Weather Conditions: Indoor

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
112			24		31.1		SAND (SW), dark grayish brown (10 YR 4/2), well sorted, fine-coarse, trace gravel, damp.	
113							GRAVELLY SAND (SP), grayish brown (10 YR 5/2), poorly graded, medium loose, damp.	
114			24		30.3			
115							SILTY SAND (SP), brown (10 YR 5/3), poorly graded, fine, medium dense, damp.	
116			24		25.6			
117								
118			24	GM-76, 116 to 120 feet, 7/9/07, 18:08	27.7			
119								
120								
121								
122								
123								
124								
125								
126								
127								

Remarks:

ARCADIS

Well Construction Log
(Unconsolidated)



6 inch diameter drilled hole

Well casing, 2 inch diameter, Schedule 40 PVC

☐ Backfill

☒ Grout Cement

66 ft*

Bentonite ☐ slurry

68 ft* ☒ pellets

70 ft*

Well Screen. 2 inch diameter Schedule 40 , 10 slot

☐ Gravel Pack

☒ Sand Pack #5

☐ Formation Collapse

80 ft*

120 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project: General Motors Corporation Well: GM-76D

Town/City: Moraine

County: Montgomery State: Ohio

Permit No.: NA

Land-Surface (LS) Elevation and Datum:

739.48 feet ☒ Surveyed ☐ Estimated

Installation Date(s): 7/10/2007

Drilling Method: Rotosonic

Drilling Contractor: Boart Longyear

Drilling Fluid: Water

Development Technique(s) and Date(s)

Pump and surge - 7/10/07

Fluid Loss During Drilling: N/A gallons

Water Removed During Development: ~45 gallons

Static Depth to Water: 29.55 feet below M.P.

Pumping Depth to Water: 87 feet below M.P.

Pumping Duration: ~.5 hours

Yield: ~1.5 gpm Date: 7/10/07

Specific Capacity: NM gpm/ft

Well Purpose: GW Monitoring

Remarks: GW Parameters (1V = 8.1 gallons)

	1V	2V	3V	4V	5V
pH:	7.64	7.17	7.10	7.11	7.01
Conductivity:	1.40	1.42	1.41	1.40	1.39
Turbidity:	0	37	0	5	6
Temperature:	20.8	20.5	20.9	20.4	20.4

Prepared by: L. Greene

ARCADIS

Soil Boring Log

Boring No.: GM-76S

Sheet: 1 of 1

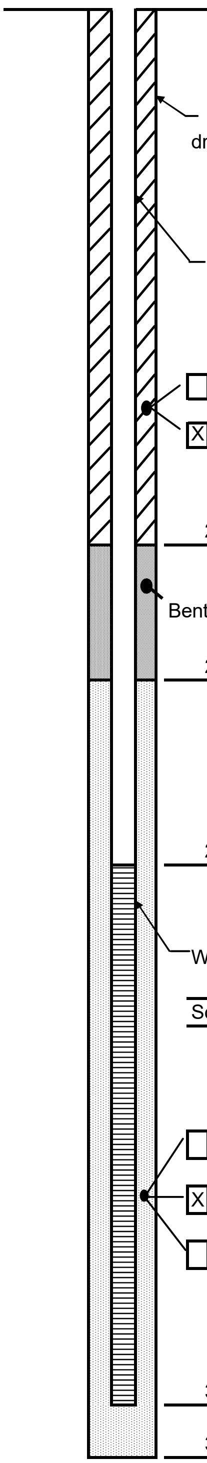
Project Name: General Motors Corporation	Date Started: 07/08/2007	Logger: L. Greene	
Project Number: OH000294.0010.00002	Date Completed: 07/08/2007	Editor: J. Hunt	
Project Location: Moraine, Ohio		Weather Conditions: Indoors	

Depth (feet)	Sample Interval	Blow Counts	Recovery (in.)	Sample ID	PID (ppm)	USCS Class	Description	Construction Details
1–37							See boring log GM-76D for lithologic description.	

Drilling Co.: Frontz	Sampling Method: Core Barrel
Driller: Dave S.	Sampling Interval: 10 feet
Drilling Method: Rotosonic	Water Level Start: NA
Drilling Fluid: Water	Water Level Finish: NA
Remarks:	Converted to Well: ☒ Yes ☐ No
	Surface Elev.: 739.49 TOC=739.00
	North Coor: 5396.6
	East Coor: 6730.8

ARCADIS

Well Construction Log
(Unconsolidated)



6 inch diameter drilled hole

Well casing,
2 inch diameter,
Schedule 40 PVC

☐ Backfill
☒ Grout Cement

23 ft*

Bentonite ☐ slurry

25 ft* ☒ pellets

27 ft*

Well Screen.
2 inch diameter
Schedule 40 , 10 slot

☐ Gravel Pack
☒ Sand Pack #5
☐ Formation Collapse

37 ft*

37 ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project General Motors Corporation Well GM-76S

Town/City Moraine

County Montgomery State Ohio

Permit No. NA

Land-Surface (LS) Elevation and Datum:

739.49 feet ☒ Surveyed ☐ Estimated

Installation Date(s) 7/8/2007

Drilling Method Rotosonic

Drilling Contractor Boart Longyear

Drilling Fluid Water

Development Technique(s) and Date(s)

Pump & surge - 7/10/07

Fluid Loss During Drilling 50 gallons

Water Removed During Development 50 gallons

Static Depth to Water 29.44 feet below M.P.

Pumping Depth to Water 35' feet below M.P.

Pumping Duration 7.00 hours

Yield ~1.5 gpm Date 9/25/07

Specific Capacity NM gpm/ft

Well Purpose GW Monitoring

Remarks GW Parameters (IV = 1.2 gallons)

	1V	2V	3V	4V	5V	6V
pH -	8.52	8.01	8.60	7.90	7.79	7.69
Conductivity:	.718	.619	.589	.640	.653	.651
Turbidity:	1	0	999	1	0	0
Temperature:	23.3	22.0	22.5	21.8	21.7	21.7

Prepared by L. Greene

SOIL BORING LOG

BORING NO.: **HFA-1**

TOTAL DEPTH: **55** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Secondary Source Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0002B**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**731.99 feet AMSL**
DATE STARTED:	**7/9/2012**	NORTHING:	**623089.9746**
DATE COMPLETED:	**8/8/2012**	EASTING:	**1484513.0188**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–1	HK	NM		CONCRETE	(0.0 - 1.0) CONCRETE removed by coring.
1–10		NM, NM, NM, NM, NM		SW	(1.0 - 10.0) SAND, medium to coarse grain, small to large round pebbles, flat and round cobbles >8 inches in diameter, trace silt, poorly sorted, loose, dry, olive brown.
10–20	35, 33	24.3, 33.6, 38.6, 42.5, 45.9		SM	(10.0 - 20.0) SAND, medium grain, some silt, few small to medium round pebbles, poorly sorted, loose, dry, olive brown.
20–28	41, 42	42.9, 46.5, 47.5, 49.6		SM	(20.0 - 28.0) SAND, fine to medium grain, some silt, few small pebbles, poorly sorted, loose, dry, olive brown. *Soil sample submitted for laboratory analysis from 26 to 28 feet.
28–30		49.7		SM	(28.0 - 30.0) SILTY SAND, medium to coarse grain, few small pebbles, round, poorly sorted, moderately stiff, wet. Note: small amount of silty clay at 30 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

Date: 12/7/2012

SOIL BORING LOG

BORING NO.: **HFA-1**

TOTAL DEPTH: **55** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Secondary Source Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0002B**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**7/9/2012**
DATE COMPLETED:	**8/8/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**731.99 feet AMSL**
NORTHING:	**623089.9746**
EASTING:	**1484513.0188**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
28–30					*Groundwater sample submitted for laboratory analysis from 28 to 32 feet.
30–32	NR	NM			(30.0 - 40.0) NO RECOVERY. Note: <1 inch silty clay in shoe at 30 feet.
32–34		NM			
34–36		NM			
36–38		NM			
38–40		NM			
40–42	24	3.8		CL	(40.0 - 45.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, very dark gray brown.
42–44		2.0			
44–46		3.0			Note: trace silt in bottom 6 inches.
45–47	58			SW	(45.0 - 52.0) SAND, medium to coarse grain with small round pebbles, few medium round pebbles, trace silt, poorly sorted, loose, wet. *Groundwater sample submitted for laboratory analysis from 47 to 52 feet.
46–48		7.8			
48–50		11.7			
50–52	NM	5.9			
52–54		5.4		CL	(52.0 - 55.0) SILTY CLAY, trace medium sand, some small to medium round pebbles, poorly sorted, hard, dry.
54–55		5.4			
55					End of boring at 55 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

SOIL BORING LOG

BORING NO.: **HFA-2**

TOTAL DEPTH: **56** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Secondary Source Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0002B**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**732.05 feet AMSL**
DATE STARTED:	**7/9/2012**	NORTHING:	**623032.0561**
DATE COMPLETED:	**8/10/2012**	EASTING:	**1484499.6284**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–2	HK	NM		CONCRETE	(0.0 - 1.5) CONCRETE and asphalt removed by coring.
2–4		NM		SW	(1.5 - 10.0) SAND, medium to coarse grain, some small to large round pebbles, few small to medium cobbles, poorly sorted, loose, dry.
4–6		NM			
6–8		NM			
8–10		NM			
10–12	42	31.2		SW	(10.0 - 11.0) SAND, medium grain, some small to medium pebbles, little silt, few small cobbles, poorly sorted, loose, wet. Note: clay fragments with black viscous material, staining, odor. *Soil sample submitted for laboratory analysis from 10 to 12 feet.
12–14		0.1		SW	(11.0 - 20.0) SAND, medium to coarse grain, some small to medium pebbles, round, poorly sorted, loose, dry, olive brown.
14–16	40	3.2			
16–18		4.1			
18–20		5.8			
20–22	44	1.2		SW	(20.0 - 24.0) SAND, medium to coarse grain, few small pebbles, trace silt, poorly sorted, loose, dry, olive brown.
22–24		3.1			
24–26		4.2		SW	(24.0 - 25.0) SAND, medium grain, little silt, poorly sorted, loose, dry to moist, olive brown.
26–28	45	5.7		SM	(25.0 - 33.0) SAND, medium grain, some small round pebbles, little clay, some silt, poorly sorted, moderately loose, wet, soft, olive brown. *Groundwater sample submitted for laboratory analysis from 25 to 30 feet.
28–		4.3			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

Date: 12/7/2012

SOIL BORING LOG

BORING NO.: **HFA-2**

TOTAL DEPTH: **56** feet bls

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Secondary Source Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0002B**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**732.05 feet AMSL**
DATE STARTED:	**7/9/2012**	NORTHING:	**623032.0561**
DATE COMPLETED:	**8/10/2012**	EASTING:	**1484499.6284**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
30–32	14	5.2			Note: some fine sand, higher silt content from 30 to 33 feet.
32–34	48	3.1			
33.0–45.0		3.3		CL	(33.0 - 45.0) SILTY CLAY, some small round pebbles, poorly sorted, hard, dry, dark gray brown.
36–38	61	2.1			
38–40		2.7			
40–42	63	2.8			Note: softer clay from 40 to 45 feet.
42–44		3.5			
44–46		8.5			
45.0–52.5	43	10.6		SM	(45.0 - 52.5) SAND, coarse grain with small to medium round pebbles, some silt, trace clay, poorly sorted, loose, dry, olive brown. *Groundwater sample submitted for laboratory analysis from 45 to 50 feet.
48–50		9.8			
50–52	48	5.9			
52.5–56.0		4.8		CL	(52.5 - 56.0) SILTY CLAY, few small to medium round pebbles, poorly sorted, hard, dry, dark gray.
54–56		3.2			
56					End of boring at 56 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

Date: 12/7/2012

SOIL BORING LOG

BORING NO.: **HFA-3**

TOTAL DEPTH: **55** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Secondary Source Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0002B**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**7/10/2012**
DATE COMPLETED:	**8/12/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**732.18 feet AMSL**
NORTHING:	**623062.7460**
EASTING:	**1484488.5266**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–1.5	HK	NM		CONCRETE	(0.0 - 1.5) CONCRETE removed by coring.
1.5–10	HK	NM, NM, NM, NM, NM		FILL	(1.5 - 10.0) SAND, medium to coarse, small to large gravel, some medium cobbles, trace silt, poorly sorted, loose, dry, brown, fill includes: metal, asphalt.
10–14	NM	3.2, 5.3		SW	(10.0 - 14.0) SAND, medium grain, some small to medium round pebbles, little silt, trace small cobbles, poorly sorted, loose, dry.
14–15.5	NM	4.5		CL	(14.0 - 15.5) SILTY CLAY, pulverized rock, small to medium round pebbles, hard, dry.
15.5–25.5	NM (15–20); 43 (20–25)	4.5, 2.5, 3.4, 6.7, 7.9		SM	(15.5 - 25.5) SILTY SAND, medium grain, few small round pebbles, poorly sorted, loose, dry. *Soil sample submitted for laboratory analysis from 22 to 24 feet. Note: becomes moist at 24.8 feet.
25.5–29.6	41	7.6, 6.7		SW	(25.5 - 29.6) SAND, medium to coarse grain, some small round pebbles, little silt, trace clay, poorly sorted, loose, wet. *Groundwater sample submitted for laboratory analysis from 25 to 30 feet.
29.6–30	41				(29.6 - 30.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, dark gray.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

Date: 12/7/2012

SOIL BORING LOG

BORING NO.: **HFA-3**

TOTAL DEPTH: **55** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Secondary Source Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0002B**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**7/10/2012**
DATE COMPLETED:	**8/12/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**732.18 feet AMSL**
NORTHING:	**623062.7460**
EASTING:	**1484488.5266**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
30–32	30	4.1		CL / SM	(30.0 - 38.0) SAND, medium to coarse grain, some silt, few small to medium round pebbles, little clay, poorly sorted, loose, soft, wet, olive brown.
32–34	41	6.4			
34–36		NM			
36–38	59	12.5			
38–40		16.8		SM	(38.0 - 40.0) SAND, fine grain, silt, poorly sorted, loose, wet, olive brown.
40–42		7.1		CL	(40.0 - 46.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, dark gray.
42–44	61	6.6			
44–46		26.6			
46–48	48	19.1		SM	*Groundwater sample submitted for laboratory analysis from 46 to 51 feet. (46.0 - 48.0) SILTY SAND, medium to coarse grain, trace small round pebbles, poorly sorted, moderately stiff, wet, gray.
48–50		4.1		SW	(48.0 - 55.0) SAND, medium to coarse grain, some small round pebbles, little silt, poorly sorted, loose, wet.
50–52	63	1.9			
52–54		1.8			
54–55		1.2			
55					End of boring at 55 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
MSL: Above Mean Sea Level
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife

SOIL BORING LOG

BORING NO.: **PSA-1**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT: **RACER Trust**
PROJECT: **Process Sump Area Investigation**
SITE LOCATION: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2012.0006A**
LOGGED BY: **Lauren Baumgartner**
DATE STARTED: **6/27/2012**
DATE COMPLETED: **7/13/2012**

DRILLING INFORMATION AMSL

DRILLING CO.: **Boart Longyear**
DRILLER: **Jason Greer**
DRILLING METHOD: **Rotosonic**

GROUND ELEVATION: **736.52 feet AMSL**
NORTHING: **622710.4301**
EASTING: **1485392.9152**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–2	HK	NM		CONCRETE	(0.0 - 0.6) CONCRETE removed by coring.
2–4		NM		SW	(0.6 - 10.0) SAND, medium to coarse grain, small to large rounded gravel, some cobble (6 in.), trace silt, poorly sorted, loose, dry, brown.
4–6		NM			
6–8		NM			
8–10		NM			
10–12	30	1.0		CL	(10.0 - 11.0) SILTY CLAY, some fine to medium sand, few small pebbles, soft, moist, very dark grayish brown.
12–14		1.8		SW	(11.0 - 20.0) SAND, fine to medium grain, trace silt, few small round pebbles, poorly sorted, loose, dry, light olive brown.
14–16		2.4			
16–18	39	2.5			
18–20		2.6			*Soil sample submitted for laboratory analysis from 18 to 20 feet.
20–22	41	0.7		SW	(20.0 - 33.5) SAND, fine to medium grain, trace silt, few small round pebbles, poorly sorted, loose, dry, light olive brown.
22–24		1.6			
24–26		1.0			Note: some medium cobbles from 24 to 25 feet.
26–28	58	1.2			Note: Wet at 27 feet. *Groundwater sample submitted for laboratory analysis from 27 to 32 feet.
28–30		1.3			
30–32	NM	1.7			
32–34		0.5			Note: some small angular pebbles from 33 to 33.5 feet.
34–36		0.6		CL	(33.5 - 42.0) SILTY CLAY, low plasticity, stiff, dry, light olive brown to very dark gray.
36–38	39	0.5			Note: very dark gray from 35 to 40 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-1**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/13/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**736.52 feet AMSL**
NORTHING:	**622710.4301**
EASTING:	**1485392.9152**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
38–40		1.2			
40–42	102	0.2			
42–44		0.4		CL	*Groundwater sample submitted for laboratory analysis from 42 to 47 feet. (42.0 - 44.0) SILTY CLAY, small angular pebbles, low plasticity, stiff, dry, light olive brown.
44–46		0.5		SP	(44.0 - 45.0) SAND, medium to coarse grain, some small to medium pebbles, silt, poorly sorted, loose, wet, light olive brown.
46–48		1.1		CL	(45.0 - 65.0) SILTY CLAY, small angular pebbles, low plasticity, hard, dry, very dark gray.
48–50		1.3			
50–52	50	2.2			Note: some large cobbles from 50 to 55 feet.
52–54		2.4			
54–56	60	1.1			
56–58		1.2			
58–60		1.0			
60–62	58	1.0			
62–64		1.0			
64–65		0.9			
65					End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

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SOIL BORING LOG

BORING NO.: **PSA-2**

TOTAL DEPTH: **53** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**737.37 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622748.0730**
DATE COMPLETED:	**7/14/2012**	EASTING:	**1485231.7515**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–10	HK	NM, NM, NM, NM, NM		CONCRETE	(0.0 - 0.6) CONCRETE removed by coring.
				SW	(0.6 - 10.0) SAND, medium to coarse grain, small to large gravel rounded, cobble (7 in.), trace silt, poorly sorted, loose, dry, brown.
10–15	40	0.2, 0.4, 1.1		SM	(10.0 - 15.0) SAND, medium to coarse grain, some silt, some small to large round pebbles, poorly sorted, loose, dry, olive brown.
15–20	34	7.6, 6.2		SM	(15.0 - 34.5) SAND, medium grain, some silt, few small to medium round pebbles, poorly sorted, loose, dry, light yellowish brown.
20–25	68	6.7, 4.5, 10.1			*Soil sample submitted for laboratory analysis from 24 to 26 feet.
25–30	50	9.6, 6.6			
30–35	50	4.2, 2.4, 1.4			*Groundwater sample submitted for laboratory analysis from 30 to 35 feet. Note: wet from 33 to 34.5 feet.
35–38	42	1.2		CL	(34.5 - 40.0) SILTY CLAY, few small angular pebbles, hard, dry, very dark gray.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-2**

TOTAL DEPTH: **53** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**737.37 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622748.0730**
DATE COMPLETED:	**7/14/2012**	EASTING:	**1485231.7515**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
38–40		1.2			
40–42	52	0.1		SM	*Groundwater sample submitted for laboratory analysis from 40 to 45 feet.
42–44		0.0			(40.0 - 52.0) SAND, medium to coarse grain, some silt, some small to large pebbles, poorly sorted, loose, wet, dark grayish brown.
44–46	80	0.6			
46–48		0.5			
48–50		0.4			
50–52		0.4			
52–53		0.3		CL	(52.0 - 53.0) SILTY CLAY, small angular pebbles, hard, dry, very dark gray.
53					End of boring at 53 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-3**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/16/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**737.83 feet AMSL**
NORTHING:	**622777.1622**
EASTING:	**1485105.5065**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0	HK	NM		CONCRETE	(0.0 - 0.6) CONCRETE, removed by coring.
2		NM		SM	(0.6 - 9.5) SAND medium to coarse grain, some silt, some small to large pebbles, few small cobbles, poorly sorted, loose, dry, dark grayish brown.
4		NM			
6		NM			
8		NM			
10	36	0.0		SM	(9.5 - 25.0) SAND medium to coarse grain, some silt, some small to large round pebbles, poorly sorted, loose, dry, very dark grayish brown.
12		0.0			
14	54	0.2			
16		0.7			
18		0.7			
20	50	0.1			Note: few small cobbles from 20 to 25 feet.
22		0.0			
24		0.0			
26	49	0.7		SM	(25.0 - 27.0) SAND, fine to medium grain, few small round pebbles, silt, poorly sorted, loose, dry, olive brown.
28		0.9		SM	(27.0 - 35.0) SAND, medium to coarse grain, some silt, some small to medium round pebbles, poorly sorted, loose, dry, olive brown.
30	44	0.9			
32		1.4			*Soil sample submitted for laboratory analysis from 32 to 34 feet.
34	48	0.4			*Groundwater sample submitted for laboratory analysis from 34 to 39 feet.
36		0.3		GW	(35.0 - 56.0) PEBBLES, small to large with medium to coarse sand, silt, poorly sorted, loose, wet,
38					

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-3**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**737.83 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622777.1622**
DATE COMPLETED:	**7/16/2012**	EASTING:	**1485105.5065**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
38		NM			olive brown.
40	52	0.2			Note: some large round pebbles from 40 to 45 feet.
42		0.3			
44	52	0.1			
46		0.2			
48		0.4			*Groundwater sample submitted for laboratory analysis from 49 to 54 feet.
50	54	1.0			
52		1.2			Note: light olive brown from 53 to 54 feet.
54		1.5			Note: dry from 55 to 56 feet.
56	84	15000			*Saturated soil sample submitted for laboratory analysis from 56 to 58 feet.
58		8599		SM	(56.0 - 63.0) SAND, very fine grain with silt, well sorted, dense, wet, olive brown.
60		1906			
62		1072			
64		82.7		CL	(63.0 - 65.0) SILTY CLAY, few small angular pebbles, hard, dry, very dark gray.
66					End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

ARCADIS

BORING NO.: **PSA-4**

TOTAL DEPTH: **64** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/26/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**736.79 feet AMSL**
NORTHING:	**622809.6554**
EASTING:	**1484968.8079**

DEPTH (feet)	Recovery (inches)	PID (ppm)
0-2	HK	NM
2-4		NM
4-6		NM
6-8		NM
8-10		NM
10-12	34	0.1
12-14		0.3
14-16		0.5
16-18	30	2.8
18-20		0.5
20-22	48	3.9
22-24		2.7
24-26		3.5
26-28	46	1.3
28-30		2.0
30-32	45	4.0
32-34		1.4
34-36		6.6

USCS Classification	SOIL DESCRIPTION
CONCRETE	(0.0 - 0.6) CONCRETE removed by coring.
SM	(0.6 - 10.0) SAND medium to coarse grain, some silt, some small to medium round pebbles, poorly sorted, loose, dry, olive brown.
SM	(10.0 - 32.0) SAND medium to coarse grain, silt, some small to medium round pebbles, poorly sorted, loose, moist, olive brown. Note: more small cobbles from 20 to 25 feet. Note: more fine to medium sand from 26 to 29.5 feet. *Soil sample submitted for laboratory analysis from 30 to 32 feet.
SM	(32.0 - 35.0) SAND, fine to medium grain, silt, some medium round pebbles, some coarse sand to small round pebbles, poorly sorted, loose, wet.
	(35.0 - 40.0) NO RECOVERY.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-4**

TOTAL DEPTH: **64** feet bls

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**736.79 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622809.6554**
DATE COMPLETED:	**7/26/2012**	EASTING:	**1484968.8079**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
36–38	NR	NM			
38–40		NM			
40–41	89	1.1		SM	(40.0 - 41.0) SAND, fine to medium grain, silt, few small round pebbles, poorly sorted, loose, wet, brown. *Groundwater sample submitted for laboratory analysis from 40 to 45 feet.
41–50		2.1, 2.2, 7.9, 31.4		SM	(41.0 - 50.0) SAND, medium to coarse grain, small to medium round pebbles, silt, poorly sorted, loose, wet, olive brown.
50–52	40	45.9		GW	(50.0 - 52.0) PEBBLES, small round, silt, poorly sorted, loose, wet, olive brown.
52–57	40 / 51	9.4, 2.2, 2.3		CL	(52.0 - 57.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, very dark gray (2.5Y 3/1).
57–60	51	5.2		ML	(57.0 - 60.0) SILT, very fine to medium sand, medium stiff, wet, dark grayish brown (2.5Y 4/2). *Saturated soil sample submitted for laboratory analysis from 58 to 60 feet. *Groundwater sample submitted for laboratory analysis from 58 to 63 feet.
60–63	30	2.3, 1.8		SM	(60.0 - 63.0) SAND, fine, silt, moderately loose, wet, dark grayish brown.
63–64				CL	(63.0 - 64.0) SILTY CLAY, few medium round pebbles, hard, very dark gray. End of boring at 64 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-85/PSA-5**

TOTAL DEPTH: **105 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**	TOP OF CASING:	**736.65 feet AMSL**
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**737.03 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622914.0083**
DATE COMPLETED:	**7/23/2012**	EASTING:	**1484978.1674**

DEPTH (feet)	USCS Classification	PID (ppm)	Recovery (inches)	SOIL DESCRIPTION
0	CONCRETE	NM	HK	(0.0 - 0.5) CONCRETE removed by coring.
2	SM	NM		(0.5 - 16.0) SAND, medium to coarse grain, some silt, some small to large round pebbles few small cobbles, poorly sorted, loose, light olive brown.
4		NM		
6		NM		
8		NM		
10		192.6	25	
12		553.5		
14		226.9	15	Note: large cobble at 13 feet. Note: rock fragments from 13 to 15 feet.
16	SM	212.7	62	(16.0 - 16.5) SILTY SAND, medium to coarse grain, small round pebbles, poorly sorted, stiff, dry, dark grayish brown.
18	SM	136.0		(16.5 - 25.0) SAND, medium to coarse grain, some silt, some small to large round pebbles, poorly sorted, loose, light yellowish brown.
20		125.4	51	
22		390.1		
24		980.6		Note: more fine to medium sand from 24 to 25 feet.
26	SM	1242	60	(25.0 - 30.0) SAND, fine to medium grain, some silt, poorly sorted, loose, moist, olive brown. *Soil sample submitted for laboratory analysis from 28 to 30 feet.
28		2791		
30	SM	142.6	60	(30.0 - 35.0) SAND, medium to coarse grain, some silt, some small round pebbles, poorly sorted, loose, olive brown. *Groundwater sample submitted for laboratory analysis from 30 to 35 feet.
32		225.1		
34		112.4		
36	GW	128.2	60	(35.0 - 45.0) PEBBLES, small and round with medium to coarse grain sand, some silt, poorly sorted, loose, wet, odor, olive brown.
38				

WELL CONSTRUCTION DETAILS

2" PVC Sch 40 Casing (0 to 85 ft)

Grout (0 to 15 ft)

Bentonite Slurry (15 to 83 ft)

Notes:

bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife

Date: 12/28/2012

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-85/PSA-5**

TOTAL DEPTH: **105 feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
CITY, STATE:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/23/2012**

DRILLING INFORMATION

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
TOP OF CASING:	**736.65 feet AMSL**
GROUND ELEVATION:	**737.03 feet AMSL**
NORTHING:	**622914.0083**
EASTING:	**1484978.1674**

DEPTH (feet)	USCS Classification	PID (ppm)	Recovery (inches)	SOIL DESCRIPTION
38–40		394.5		
40–42		1048	60	
42–44		>15000		
44–46	SM	>15000		(45.0 - 50.0) SAND, medium to coarse grain with small round pebbles, few large round pebbles, silt, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 45 to 50 feet.
46–48		>15000	58	
48–50		>15000		
50–52	CL	>15000	8	(50.0 - 58.0) SILTY CLAY, few small pebbles, hard, dry. *Saturated soil sample submitted for laboratory analysis from 54 to 56 feet.
52–54		221.3	120	
54–56		>15000		
56–58		117.2		
58–60	SM	891.2	120	(58.0 - 62.0) SAND, very fine with silt, dense, wet, olive brown. *Saturated soil sample submitted for laboratory analysis from 60 to 62 feet.
60–62		491.2		
62–64	CL	379.2		(62.0 - 69.0) SILTY CLAY, hard, some small round pebbles, dry, very dark gray. Note: higher silt content from 65 to 69 feet.
64–66		303.5		
66–68		185.5	75	
68–70	SM	15.2		(69.0 - 74.0) SAND, medium to fine grain, silt, some small to medium round pebbles, poorly sorted, loose, wet, dark grayish brown. *Groundwater sample submitted for laboratory analysis from 69 to 74 feet.
70–72		10.1	42	
72–74		205.5		
74–76	ML	245.8		(74.0 - 75.0) SILT, moderately stiff, wet, light olive brown.

WELL CONSTRUCTION DETAILS

Bentonite Slurry (15 to 83 ft)

Notes:

bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife

Date: 12/28/2012

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-85/PSA-5**

TOTAL DEPTH: **105 feet bls**

PROJECT INFORMATION

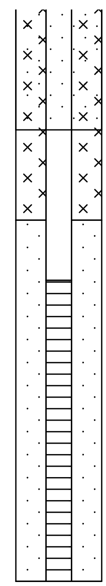
CLIENT: **RACER Trust**
PROJECT: **Process Sump Area Investigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2012.0006A**
LOGGED BY: **Lauren Baumgartner**
DATE STARTED: **6/27/2012**
DATE COMPLETED: **7/23/2012**

DRILLING INFORMATION

DRILLING CO.: **Boart Longyear**
DRILLER: **Jason Greer**
DRILLING METHOD: **Rotosonic**
TOP OF CASING: **736.65 feet AMSL**
GROUND ELEVATION: **737.03 feet AMSL**
NORTHING: **622914.0083**
EASTING: **1484978.1674**

DEPTH (feet)	USCS Classification	PID (ppm)	Recovery (inches)	SOIL DESCRIPTION
76–78	SM	78.1	150	(75.0 - 85.0) SAND, fine to medium grain, silt, few small to medium round pebbles, poorly sorted, loose, wet, light olive brown.
78–80		449		
80–82		13.5	NM	
82–84		31.2		
84–86		20.5		
85–88	GW	10.2	NM	(85.0 - 105.0) PEBBLES, small, sand medium to coarse grain, silt, few medium to large pebbles, poorly sorted, loose, wet, dark olive brown. * Groundwater sample submitted for laboratory analysis from 85 to 90 feet.
88–90		7.9		
90–92		9.9	160	Note: more fine to medium sand from 90 to 100 feet.
92–94		15.2		
94–96		3.8		
96–98		3.4		
98–100		3.0		
100–102		2.1		*Groundwater sample submitted for laboratory analysis from 100 to 105 feet.
102–104		2.1		
104–105		2.0		
105				End of boring at 105 feet.

WELL CONSTRUCTION DETAILS



Bentonite Slurry (15 to 83 ft)

Sand Pack (83 to 95 ft)

2" Screen slot size 0.10 (85 to 95 ft)

Formation collasped from (95 to 105 ft)

Notes:
bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife

Date: 12/28/2012

SOIL BORING LOG

BORING NO.: **PSA-6**

TOTAL DEPTH: **70** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**736.66 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**632011.4770**
DATE COMPLETED:	**7/27/2012**	EASTING:	**148500.9137**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0–2	HK	NM	CONCRETE	(0.0 - 0.5) CONCRETE, removed by coring.
2–4		NM	SM	(0.5 - 10.0) SAND, medium to coarse grain, silt, small to medium pebbles, few small cobbles, poorly sorted, loose, dry. Note: at 0.5 feet 3-inch layer of tar like substance is observed on the east side of the borehole.
4–6		NM		
6–8		NM		
8–10		NM		
10–12	41	0.0	SW	(10.0 - 20.0) SAND, medium grain, some small round pebbles, trace silt, poorly sorted, loose, dry, light olive brown.
12–14		0.7		
14–16	43	0.0		
16–18		0.0		Note: cobble (6 inches) at 16 feet.
18–20		0.0		
20–22	89	0.1	SM	(20.0 - 30.0) SAND, medium grain, some small pebbles, trace small cobbles, silt, poorly sorted, loose, dry, light olive brown.
22–24		1.1		Note: increase in small pebbles from 22 to 24 feet. *Soil sample submitted for laboratory analysis from 22 to 24 feet.
24–26		1.0		
26–28		0.5		
28–30		2.3		Note: moist from 29 to 30 feet. *Groundwater sample submitted for laboratory analysis from 29 to 34 feet.
30–32	40	5.2	SC	(30.0 - 33.0) SAND with silty clay, some small pebbles, poorly sorted, low plasticity, soft, moist, olive brown.
32–34		7.8	CL	(33.0 - 38.0) SILTY CLAY, few small rounded pebbles, poorly sorted, hard, dry, very dark, grayish brown.
34–36	36	36.2		

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

ARCADIS

BORING NO.: **PSA-6**

TOTAL DEPTH: **70** feet bls

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/27/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**736.66 feet AMSL**
NORTHING:	**632011.4770**
EASTING:	**148500.9137**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
36–38		32.4		Note: cobble from 36 to 37 feet.
38–40	24	38.7	SC	(38.0 - 42.0) SAND with silty clay, medium to coarse grained sand, some small pebbles, poorly sorted, moist, grayish brown.
40–42	48	158.2		
42–44		345.8	CL	(42.0 - 46.0) SILTY CLAY, few to some small to medium angular pebbles, hard, low plasticity, dry, grayish brown. Note: negative result for NAPL test from 42 to 44 feet. *Groundwater sample submitted for laboratory analysis from 42 to 47 feet.
44–46	54	18.8		
46–48		55.3	CL-ML	(46.0 - 50.0) CLAYEY SILT with sand, medium grained sand, some small to large pebbles, low plasticity, dry, light gray. Note: cobble at 48 feet.
48–50		1.2		
50–52	84	1487	CL	(50.0 - 54.0) SILTY CLAY, few to some small angular pebbles, hard, low plasticity, dry, dark grayish brown. *Saturated soil sample sumbitted for laboratory analysis from 50 to 52 feet. *Groundwater sample submitted for laboratory analysis from 52 to 57 feet. Note: negative result for NAPL test from 50 to 54 feet.
52–54		229.7		
54–56		89.1	SW	(54.0 - 56.0) SILTY SAND, medium grained sand, few to some medium to large rounded pebbles, poorly sorted, moist, olive brown.
56–58	36	178.4	ML	(56.0 - 58.0) SILT, some fine to medium grained sand, some small rounded pebbles, poorly sorted, moist, olive brown.
58–60		11,094	SM	(58.0 - 60.0) SAND with gravel, some silt, some small to medium rounded pebbles, poorly sorted, wet, strong odor, olive-brown. Note: positive result for NAPL test from 58 to 60. *Saturated soil sample submitted for laboratory analysis from 58 to 60 feet.
60–62	56	9,882	CL	(60.0 - 68.0) SILTY CLAY, few to small angular pebbles, hard, low plasticity, dry, dark grayish brown. Note: Negative result for NAPL test from 60 to 66 feet. *Saturated soil sample submitted for laboratory analysis from 66 to 68 feet. Note: increasing silt content, brown at 67 feet.
62–64		2,782		
64–66	54	378.5		
66–68		49.1		
68–70		13.8	SM	(68.0 - 70.0) SAND with gravel, some silt, some rounded small pebbles, poorly sorted, loose, wet, olive brown.

End of boring at 70 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-7**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/28/2012**
DATE COMPLETED:	**7/29/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**737.04 feet AMSL**
NORTHING:	**623107.7413**
EASTING:	**1485023.3387**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0	HK	NM		CONCRETE	(0.0 - 0.6) CONCRETE removed by coring.
2		NM		SM	(0.6 - 10.0) SAND, medium to coarse grain, silt, small to medium, pebbles, few small cobbles, poorly sorted, loose, dry.
4		NM			
6		NM			
8		NM			
10	57	4.9		SW	(10.0 - 20.0) SAND, medium grained, some small round pebbles, trace silt, poorly sorted, loose, dry, light olive brown.
12		34.6			*Soil sample submitted for laboratory analysis from 12 to 14 feet.
14	42	4.2			Note: cobble at 14 feet.
16		3.9			
18		4.4			
20	50	1.0		SM	(20.0 - 32.0) SAND, medium grained, some small to medium pebbles, trace small cobbles, silt, poorly sorted, loose, dry, light olive brown.
22		2.3			
24	44	4.9			Note: decrease in pebbles from 25 to 30 feet.
26		7.8			Note: moist from 26 to 30 feet.
28		8.3			*Grounwater sample submitted for laboratory analysis from 29 to 34 feet.
30	60	7.7			Note: increase in small to medium rounded pebbles at 30 feet.
32		18.2		SC	(32.0 - 34.0) SAND with silty clay, some small rounded pebbles, poorly sorted, loose, moist, olive brown.
34		21.7		CL	(34.0 - 38.0) SILTY CLAY, few small round pebbles, hard, low plasticity, dry, very dark grayish brown.
36					

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-7**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**737.04 feet AMSL**
DATE STARTED:	**6/28/2012**	NORTHING:	**623107.7413**
DATE COMPLETED:	**7/29/2012**	EASTING:	**1485023.3387**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
36–38	56	213.8			Note: negative result for NAPL test from 36 to 38 feet.
38–40		141.2		SC	(38.0 - 40.0) SAND with silty clay, medium to coarse grained sand, some small rounded pebbles, poorly sorted, moist, grayish brown. Note: negative result for NAPL test from 38 to 40 feet.
40–42	54	5.2		SM	(40.0 - 48.0) SAND with gravel, medium to coarse sand, some silt, some small rounded pebbles, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 40 to 45 feet.
42–44		5.5			
44–46	40	6.8			
46–48		30.7			
48–50		989.9		CL	(48.0 - 52.0) SILTY CLAY, few to some small angular pebbles, hard, low plasticity, dry, dark grayish brown. *Saturated soil sample submitted for laboratory analysis from 50 to 52 feet. Note: negative result for NAPL test from 48 to 50 feet. Note: negative result for NAPL test from 50 to 52 feet. Note: negative result for NAPL test from 52 to 54 feet. *Saturated soil sample submitted for laboratory analysis from 52 to 54 feet.
50–52	42	2204			
52–54		244.6		SM	(52.0 - 64.0) SILTY SAND, medium grained sand, trace small angular pebbles, trace silt, well sorted, loose, wet, light olive brown.
54–56	48	190.1			
56–58		73.1			
58–60		31.9			*Groundwater sample submitted for laboratory analysis from 59 to 64 feet.
60–62	54	36.1			Note: grades to medium grained sand, increasing silt content from 60 to 64 feet.
62–64		7.4			
64–65		2.2		CL	(64.0 - 65.0) SILTY CLAY, few small rounded pebbles, hard, low plasticity, dry, dark grayish brown. End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-8**

TOTAL DEPTH: **66.5 feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**7/31/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.73 feet AMSL**
NORTHING:	**623024.1416**
EASTING:	**1485082.2288**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–2	HK	NM		CONCRETE	(0.0 - 0.5) CONCRETE removed by coring.
2–4		NM		SM	(0.5 - 10.0) SAND, medium to coarse grain, some silt, some small to large round pebbles, few small cobbles, poorly sorted, loose, dry, olive brown.
4–6		NM			
6–8		NM			
8–10		NM			
10–12	53	2.1		SW	(10.0 - 20.0) SAND, medium grained, some small to large pebbles, poorly sorted, loose, dry, light yellowish brown.
12–14		2.2			
14–16		2.4			
16–18	48	2.2			
18–20		1.9			Note: cobble from 17 to 20 feet.
20–22	47	2.1		SW	(20.0 - 34.0) SAND, medium grained, some small to large rounded pebbles, trace silt, poorly sorted, loose, dry, light olive brown (2.5Y 5/3).
22–24		4.2			
24–26		6.6			Note: olive brown at 25 feet.
26–28	50	8.3			
28–30		4.4			
30–32	45	12.9			Note: moist at 30 feet. *Soil sample submitted for laboratory analysis from 32 to 34 feet.
32–34		85.0			*Groundwater sample submitted for laboratory analysis form 31 to 36 feet.
34–36	24	180.9		SC	(34.0 - 36.0) SAND with silty clay, medium grained sand, few rounded pebbles, poorly sorted, wet, olive brown. Note: negative result for NAPL test from 34 to 36 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

ARCADIS

SOIL BORING LOG

BORING NO.: **PSA-8**

TOTAL DEPTH: **66.5 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**738.73 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**623024.1416**
DATE COMPLETED:	**7/31/2012**	EASTING:	**1485082.2288**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
36–38	81	183.3	CL	Note: negative result for NAPL test from 36 to 38 feet.
38–40		181.1		(36.0 - 43.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, dry, very dark grayish brown. Note: negative result for NAPL test from 38 to 40 feet.
40–42		575.4		Note: very hard material is fractured from 40 to 43 feet. Note: negative result for NAPL test from 40 to 42 feet.
42–44	71	180.4		*Groundwater sample submitted for laboratory analysis from 43 to 48 feet.
44–46		165.8	SM	(43.0 - 50.0) SAND, coarse grain with silt, some medium to large pebbles, poorly sorted, loose, wet, olive brown. Note: negative result for NAPL test from 44 to 46 feet.
46–48		115.8		Note: negative result for NAPL test from 46 to 48 feet.
48–50		83.2		
50–52	24	392	CL	(50.0 - 52.0) SILTY CLAY, some small pebbles, poorly sorted, hard, dry, very dark grayish brown. Note: negative result for NAPL test from 50 to 52 feet.
52–54	NM	233.4	ML	(52.0 - 56.0) SANDY SILT with clay, medium to coarse grain sand, few small to medium pebbles, poorly sorted, loose, moist to wet, odor, olive brown.
54–56		10,887		
56–58		11,901	SM	(56.0 - 58.0) SILTY SAND, medium to coarse grain with some small to medium pebbles, poorly sorted, loose, moist to wet, odor, olive brown. *Saturated soil sample submitted for laboratory analysis from 56 to 58 feet.
58–60		9,029	ML	(58.0 - 60.0) SILT, few small pebbles, fractured/crumbled, hard, odor, olive brown (2.5Y 3/2).
60–62	24	298.2	SW	(60.0 - 62.0) SAND, medium to coarse grain, few small pebbles, trace silt, poorly sorted, loose, wet. Note: negative result for NAPL test from 60 to 62 feet. *Groundwater sample submitted for laboratory analysis from 61 to 66 feet. Note: more silt at 61.5 feet.
62–64	36	268.1	ML	(62.0 - 66.0) SILT with very fine sand, stiff, wet, odor, olive brown. Note: negative result for NAPL test from 62 to 64 feet.
64–65		255.4		Note: negative result for NAPL test from 64 to 66 feet.
65–66.5	48	38.1	CL	(66.0 - 66.5) SILTY CLAY, trace small round pebbles, hard. Note: negative result for NAPL test from 66 to 66.5 feet.

End of boring at 66.5 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-9**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**738.81 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622912.6158**
DATE COMPLETED:	**8/7/2012**	EASTING:	**1485207.1184**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0 - 2	HK	NM		CONCRETE	(0.0 - 0.5) CONCRETE removed by coring.
				SM	(0.5 - 10.0) SAND, medium to coarse grain, some silt, some small to medium round pebbles, few small cobbles, poorly sorted, loose, dry.
2 - 4		NM			
4 - 6		NM			
6 - 8		NM			
8 - 10		NM			
10 - 12	35	3.2		SM	(10.0 - 20.0) SAND, fine to medium grain, silt, some small to medium pebbles, poorly sorted, loose, dry, olive brown.
12 - 14		3.6			
14 - 16	34	3.4			Note: higher silt content, olive brown from 15 to 20 feet.
16 - 18		1.1			
18 - 20		3.9			
20 - 22	45	2.1		GW	(20.0 - 21.0) PEBBLES, small to medium, trace coarse sand, poorly sorted, loose, dry, olive brown.
				ML	(21.0 - 30.0) SILT with fine to medium sand, few medium round pebbles, poorly sorted, loose, dry, olive brown (2.5Y 4/3).
22 - 24		3.3			
24 - 26	38	2.2			
26 - 28		6.3			Note: more medium round pebbles with depth from 26 to 30 feet. *Soil sample submitted for laboratory analysis from 26 to 28 feet.
28 - 30		6.1			
30 - 32	NR	NM			(30.0 - 32.0) NO RECOVERY.
32 - 34		2.1		SW	(32.0 - 40.0) SAND with small pebbles, medium to coarse sand, few medium pebbles, little silt, poorly sorted, loose, wet, olive brown. *Groundwater sample submitted for laboratory analysis from 32 to 37 feet.
34 - 36		2.6			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-9**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2012.0006A**
LOGGED BY:	**Lauren Baumgartner**
DATE STARTED:	**6/27/2012**
DATE COMPLETED:	**8/7/2012**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Boart Longyear**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.81 feet AMSL**
NORTHING:	**622912.6158**
EASTING:	**1485207.1184**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
36	48	5.2			Note: higher silt content, some clay, wet from 36 to 40 feet.
38		2.2			
40		2.4		ML	(40.0 - 42.0) SILT, little fine grain sand, loose, wet, olive brown.
42	33	4.2		SM	(42.0 - 50.0) SAND, fine to coarse grain with silt, few small to medium round pebbles, poorly sorted, loose, wet, olive brown.
44		8.4			
46	34	9.3			Note: higher silt content, wet from 45 to 50 feet.
48		8.2			*Groundwater sample submitted for laboratory analysis from 47 to 52 feet.
50	18	11.3		SM	(50.0 - 54.0) SILTY SAND, medium to coarse grain, few medium pebbles to small cobbles, trace clay, poorly sorted, loose to moderately stiff, wet, olive brown.
52	34	5.7			Note: more consolidated with depth from 52 to 54 feet.
54		17.8		CL	(54.0 - 59.0) SILTY CLAY, few medium round pebbles, poorly sorted, hard, dry, dark gray brown.
56	33	13.8			Note: dry, slight odor from 55 to 59 feet.
58		73.9		SM	(59.0 - 60.0) SILTY SAND, fine to medium grain, few small to medium pebbles, moderately stiff, wet, very dark gray. *Groundwater sample submitted for laboratory analysis from 59 to 64 feet.
60	41	46.9		SM	(60.0 - 64.0) SAND, medium to coarse grain with silt, few small round pebbles, poorly sorted, loose, wet, dark gray brown.
62		108.7			Note: increased silt content with depth.
64		73.8		ML	(64.0 - 64.5) SILT, few small round pebbles, trace sand, poorly sorted, moderately stiff, slight odor, moist.
66				CL	(64.5 - 65.0) SILTY CLAY, few small round pebbles, poorly sorted, hard, slight odor, dry.

End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-10**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**738.77 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622869.8232**
DATE COMPLETED:	**8/28/2012**	EASTING:	**1485368.4397**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–10	HK	NM, NM, NM, NM, NM		CONCRETE	(0.0 - 0.8) CONCRETE removed by coring.
				SM	(0.8 - 10.0) SAND, medium to coarse grain, silt, some small to medium round pebbles, few small cobbles, poorly sorted, loose, dry, olive brown.
10–15	36	1.4, 1.2, 0.5		SM	(10.0 - 15.0) SAND, medium grain, some silt, some small to large round pebbles, poorly sorted, loose, dry, olive brown.
15–20	34	1.9, 2.0		SW	(15.0 - 16.0) SAND, medium grain, few small round pebbles, trace silt, poorly sorted, loose, dry, olive brown.
				SW	(16.0 - 32.0) SAND, medium grain, some small to large round pebbles, poorly sorted, loose, dry, light olive brown.
20–25	42	1.4, 1.4, 2.4			Note: cobbles at 23 feet.
25–30	40	2.1, 2.8			Note: higher silt content, more medium round pebbles from 25 to 30 feet.
30–33	29	3.0			*Soil sample submitted for laboratory analysis from 30 to 32 feet.
33–35	30	2.9, 2.6		CL	(32.0 - 45.0) SILTY CLAY, some small round pebbles, poorly sorted, loose, dry, gray.
35–38	48	0.8			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 12/11/2012

ARCADIS

SOIL BORING LOG

BORING NO.: **PSA-10**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Boart Longyear**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2012.0006A**		
LOGGED BY:	**Lauren Baumgartner**	GROUND ELEVATION:	**738.77 feet AMSL**
DATE STARTED:	**6/27/2012**	NORTHING:	**622869.8232**
DATE COMPLETED:	**8/28/2012**	EASTING:	**1485368.4397**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
38–39		1.4			
40–41	52	2.1			Note: more small round pebbles, higher silt content from 40 to 45 feet.
42–43		2.0			
44–45		1.8			(45.0 - 45.5) SILTY CLAY, some small to medium round pebbles, little medium sand, poorly sorted, soft, moist to wet, olive brown.
45–46.5		2.0		CL / SM	(45.5 - 46.5) SAND, coarse grain with silt, some small to medium round pebbles, little clay, loose to moderate stiff, wet, olive brown.
48–49		4.5		CL	(46.5 - 65.0) SILTY CLAY, some small to medium round pebbles, trace sand, poorly sorted, hard, dry, gray.
50–51		7.0			*Groundwater sample submitted for laboratory analysis from 45 to 50 feet.
52–53		8.3			
54–55	120	8.5			
56–57		9.3			Note: seams of medium sand, well sorted from 55 to 56 feet.
58–59		12.2			Note: more medium round pebbles from 58 to 60 feet.
60–61		7.2			
62–63	78	5.3			
64–65		3.4			Note: higher silt content from 64.5 to 65 feet. End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 12/11/2012

SOIL BORING LOG

BORING NO.: **PSA-11**

TOTAL DEPTH: **68** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.84**
DATE STARTED:	**12/29/2014**	NORTHING:	**622959.301**
DATE COMPLETED:	**12/30/2014**	EASTING:	**1485092.839**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–3	Hand Auger	NM		HAND AUGER	(0.0 - 3.0) HAND AUGER.
3–8	53	0.7 0.7 0.6		ML	(3.0 - 10.0) SILT, and fine to medium sand, some small to large pebbles, slow dilatancy, wet, soft, brown.
8–13	139	0.7 0.3 1.2		SW	(10.0 - 18.0) SAND, fine, some small to large pebbles, well sorted, loose, dry, brown. Note: At 12 to 14 feet increase in pebble size.
13–18	120	0.6 0.3			
18–23	86	*5.5 2.5 4.2		SP	(18.0 - 28.0) SAND, very fine to fine, some small to medium pebbles, poolry sorted, dry, very loose, brown. Note: At 20 to 24 feet dry. Note: At 24 to 28 feet increase in pebbles, dry.
23–28	120	5.1 *1.8			
28–33	73	*0.9 *2.2 2.7		SP	(28.0 - 38.0) SAND, coarse, with graunles, some small to very large pebbles, poorly sorted, wet. Note: At 30 to 32 feet medium to coarse sand.
33–38	120	3.1 6.4			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-11**

TOTAL DEPTH: **68** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.84**
DATE STARTED:	**12/29/2014**	NORTHING:	**622959.301**
DATE COMPLETED:	**12/30/2014**	EASTING:	**1485092.839**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
38	141	1.8		SM	(38.0 - 42.0) SAND and silty clay, medium to coarse, some large to small cobbles, poorly sorted, wet, loose, brown.
40		27.0			Note: At 41 feet decrease in pebbles, more silty clay.
42		*75.2		SM	(42.0 - 43.0) SAND, fine with silty clay, trace pebbles, poorly sorted, wet, brown.
44	120	*63.8		CL	(43.0 - 49.0) Silty CLAY and fine sand, medium plasticity, slow dilatancy, wet, soft, brown.
46		*48.7			
48	124	85.1		CL	(49.0 - 52.0) CLAY and silt, some medium to large pebbles, low plasticity, no dilatancy, dry, stiff.
50		710.8			
52	120	*444.5		ML	(52.0 - 59.0) SILT and fine sand, some clay, moist, soft, gray.
54		199.2			Note: At 54 to 56 feet moisture increases.
56		384.2			Note: At 56 to 58 feet, increase in sand, fine to medium, moist to wet.
58	125	*67.2		ML	(59.0 - 64.0) SILT and very fine sand, low plasticity, rapid dilatancy, wet, medium stiff, gray.
60		*23.6			
62	120	*73.3			
64		39.1		CL	(64.0 - 68.0) CLAY, some silt, no dilatancy, dry, hard, dark gray.
66		25.5			Note: At 67 feet fractured clay.
68					End of Boring at 68 feet.
70					
72					
74					

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-12**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**Chris Kassel**
DATE STARTED:	**11/10/2014**
DATE COMPLETED:	**11/11/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Cascade**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.86**
NORTHING:	**623194.827**
EASTING:	**1485123.242**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0	VAC Truck	0.1		FILL	(0.0 - 16.4) FILL, coarse sand and sub-rounded pebbles, loose, little silt and clay, poorly sorted, moist, brown.
2		0.1			Note: At 2 to 6 feet trace silt or clay, well sorted, moist.
4		0.2			
6		0.4			Note: At 6 to 10 feet dry, fining downward from coarse sand to medium sand, soft, pebbles, trace sub-angular granules.
		0.6			
8	24	0.8			
		1.2			
10	79	1.5			
12		3.0			
14		3.7			
		3.7			
16		1.8		CL	(16.4 - 20.0) Silty CLAY, few sub-rounded granules, trace fine to medium sand, low plasticity, dry, hard, light gray.
18		1.7			
		3.3			
20	43	1.2		SW	(20.0 - 22.5) SAND, medium, trace sub-rounded medium to small pebbles and granules, well sorted, moist, brown.
		2.5			
22		5.0		CL	(22.5 - 25.0) Silty CLAY, trace sub-rounded small pebbles, low to medium plasticity, dry, hard, light gray.
24		6.7			
25	56	1.9		SW	(25.0 - 31.0) SAND, medium, few granules, trace small to medium pebbles, sub-rounded, loose, moist, fining downward.
26		1.8			
		1.8			
28		3.6			
		3.3			
30	69	2.0			Note: At 30.8 to 31.3 feet two large pebbles in top foot, moisture increases with depth.
		*2.0		SW	(31.0 - 33.0) SAND, medium to coarse, few granules and small pebbles, sub-rounded, well sorted, wet, brown.
32		*1.9			
		2.2		CL	(33.0 - 56.0) Silty CLAY, trace sand and granules, sub-angular medium plasticity, hard, moist,
34		1.0			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-12**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**Chris Kassel**
DATE STARTED:	**11/10/2014**
DATE COMPLETED:	**11/11/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Cascade**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.86**
NORTHING:	**623194.827**
EASTING:	**1485123.242**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
35-40	65	4.3, 4.6, 1.2, 1.5, 0.9		CL	becoming dry with depth, light gray.
40-45	65	1.5, 1.2, 1.8, 1.1, 1.5		CL	Note: Begining at 42.6 feet small to medium pebbles, rounded.
45-50	75	0.4, 0.4, 1.0, 0.4, 0.4, 0.2, 0.3		CL	Note: At 45 feet granules more cohesive, moist.
50-55	84	0.2, 0.3, 0.9, 0.6, 0.5, 1.6, *1.0		CL	
55-56	63	*27.9		CL	
56-58		*50.1, *108.1, *3.3		SW	(56.0 - 58.0) SAND, coarse, few small to medium pebbles, sub-round, trace silt, well sorted, wet, loose, light gray.
58-60		53.1		CL	(58.0 - 60.0) Silty CLAY, coarse sand, few very fine to fine sand, medium to high plasticity, no pebbles, moist, light gray.
60-64	65	*3.4, *0.8, *0.8, *0.9		SW	(60.0 - 64.0) SAND, fine, few silt, trace clay, low dilatancy, well sorted, wet, soft, coarsening downward to medium, brown.
64-65		*0.9, *1.0		CL	(64.0 - 65.0) Silty CLAY, some coarse sand, few very fine to fine sand, trace clay and sub-angular granules, medium plasticity, moist.
					End of boring at 65 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

BORING/WELL CONSTRUCTION LOG

ARCADIS

WELL NO.: **RMW-89 (PSA-13)**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**	TOP OF CASING:	**738.56**
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	
DATE STARTED:	**12/10/2014**	NORTHING:	**623067.549**
DATE COMPLETED:	**12/15/2014**	EASTING:	**1485313.452**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–2	VAC TRUCK	0.2	CONCRETE	(0.0 - 0.7) CONCRETE.	Flush Mount (0 to 1 ft)
2–4		0.3	GC	(0.7 - 4.0) Silty CLAY with sub-angular pebbles, moist, hard, high plasticity becomes less plastic and clay-rich with depth, light brown.	
4–6		0.1	SM	(4.0 - 6.0) SAND, medium, trace silt, few pebbles, moist, brown.	
6–8		0.1	SW	(6.0 - 9.7) SAND, medium to fine, trace pebbles, moist, loose, light brown.	
8–10	24	0.2		Note: At 8 to 9.7 feet wet, dark brown, with some clay, low plasticity.	
10–15	52	1.1, 1.5, 0.5, 3.5, 10.	SP	(9.7 - 22.2) SAND fine to medium, trace silt, few angular pebbles, loose, dry, light brown. Note: At 10 to 12 feet pebbles becomes sub-round with depth, trace granules, trace coarse sand.	Bentonite (1 to 36 ft)
15–20	48	1.5, 4.9, 3.0, 0.4, 0.3		Note: At 16 feet fewer pebbles with depth, pebbles are trace and small.	
20–25	50	1.5, 3.0, 4.3, 3.8, 0.9		Note: At 20 feet no pebbles.	
			SW	(21.2 - 23.5) SAND, medium, trace silt, trace granules, well sorted, non-plastic, dry, loose, light brown.	
			SM	(23.5 - 28.5) SAND, fine, and silt, non-plastic, hard to loose, well sorted, dry, light brown.	
25–30	65	1.6, 1.4, 1.8, 0.5, 0.5		Note: At 28 feet some pebbles.	
30–34	33	0.7, 3.5, *9.7, *1.2	GW	(28.5 - 39.0) SAND, coarse, some angular to sub-rounded pebbles and granules, few medium sand, trace silt, sub-round, well sorted, dry, loose, dark brown. Note: At 31 feet wet.	

Notes:

bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife
AMSL: Above Mean Sea Level

Date: 2/27/2015

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-89 (PSA-13)**

TOTAL DEPTH: **65** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**	TOP OF CASING:	**738.56**
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	
DATE STARTED:	**12/10/2014**	NORTHING:	**623067.549**
DATE COMPLETED:	**12/15/2014**	EASTING:	**1485313.452**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
34–35		*0.4	GW	Note: At 35 to 38 feet trace small cobbles sub-angular, trace clay, wet, poorly sorted, non-plastic.	
35–40	63	*0.6, *0.8, 0.3, 1.0	GW	Note: At 38 feet granules, few coarse sand, light brown.	Sand Pack (38 to 52 ft)
39–40			SP	(39.0 - 40.0) SAND, coarse, some pebbles, angular to sub-round, trace silt, non-plastic, loose, wet, light brown.	
40–45	65	0.1, 0.3, 0.4, 0.7, 0.6	GW	(40.0 - 45.0) GRANULES, some coarse to medium sand, trace pebbles, trace silt, well sorted, wet, loose, sub-rounded, light brown. Note: At 44 to 45 feet small cobbles, sub-rounded to sub-angular.	2" Schedule 40 PVC Screen, slot size 0.010 (40.7 to 50.70 ft)
45–50	65	0.5, *0.6, *1.1, *1.2, *1.5	SW	(45.0 - 51.0) SAND, coarse, trace silt, soft, wet, dark brown. Note: At 46 feet coarsening doward to granules and pebbles, some cobbles, angular to sub-rounded.	
50–55	67	*0.6, *0.9, 0.5, 0.4, 0.7	CL	(51.0 - 65.0) Silty CLAY, medium plasticity, moist, trace sub-angular granules, dry, hard, light gray. Note: At 55 feet moist.	Bentonite (52 to 65 ft)
55–60	79	0.4, 0.6, 0.5, 0.5, 0.5	CL	Note: At 56 feet silt and fine sand, trace clay, low plasticity, moist. Note: At 56.5 feet silty clay, medium plasticity, trace sub-angular granules. Note: At 58 feet fine sand, low plasticity. Note: At 58.5 feet medium plasticity, trace sub-angular granule.	
60–65	75	0.6, 0.6, 0.5, 0.9, 1.5	CL		
65				End of boring at 65 feet.	

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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife
AMSL: Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-14**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	**738.88**
DATE STARTED:	**11/3/2014**	NORTHING:	**623233.265**
DATE COMPLETED:	**11/7/2014**	EASTING:	**1485501.312**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0–2	VAC TRUCK	0.3	CONCRETE	(0.0 - 0.8) CONCRETE.
2–6		0.1, 0.1	SP	(0.8 - 6.0) SAND, medium, with few granules and small pebbles, sub-round, loose, coarsening downward to large pebbles at base, more angular pebbles with depth, poorly sorted, moist, brown.
6–8		0.4, 0.8	SW	(6.0 - 23.0) SAND, medium to coarse, few granules to large pebbles, round, dry, loose. Note: At 7 feet brown. Note: At 18 to 20 feet blocky sand, medium, few granules, large pebbles, dark brown. Note: At 20 to 23 feet few sub-angular granules, trace sub-angular pebbles.
8–10	24	1.0, 0.9		
10–15	78	1.4, 2.0, 2.4, 6.2, 2.8		
15–20	76	1.8, 1.0, 1.3, 1.2, 1.1		
20–25	77	3.5, 2.0, 3.2, 2.1, 3.3	SW (23.0)	(23.0 - 30.0) SAND, medium, some fine to very fine sand, trace silt, and granules, loose, well sorted, dry, light brown. Note: At 28.5 feet black, moist.
25–35	90	1.5, 2.5, 4.1, 2.5, 3.9, 2.4, *1.7, *1.5, *4.7	SP (30.0)	(30.0 - 35.0) SAND, coarse, few pebbles, sub-angular to sub-rounded, trace silt, fine sand, trace large pebbles, poorly sorted, wet, light brown.
35–40	48	0.9, 1.8, 2.8	SP	(35.0 - 40.0) SAND, coarse, few sub-angular to sub-round pebbles, trace silt and fine sand, coarsening downward with pebbles becoming more angular with depth, few large pebbles at base, low pasticity, wet, poorly sorted, trace clay.
40–45	61	0.6, 1.9, 1.7, 1.0, 2.0	GW	(40.0 - 48.5) PEBBLES, with few coarse sand, trace silt, coarsening downward to small cobbles, sub-rounded to sub-angular, well sorted, wet, loose, light brown. Note: At 42 feet trace sand. Note: At 44 feet few medium sand, trace silt, trace clay.
45–50	63	*2.4, *4.0, *4.5, *8.5, *7.7	CL (48.5)	(48.5 - 58.0) Silty CLAY, few coarse sand, trace small pebbles, sub-rounded, low to meidum plasticity, moist, stiff, light gray.
50–52		2.0, 0.1		

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NR: No Recovery
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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-14**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	**738.88**
DATE STARTED:	**11/3/2014**	NORTHING:	**623233.265**
DATE COMPLETED:	**11/7/2014**	EASTING:	**1485501.312**

DEPTH (feet)	Recovery (inches)
52 - 55	72
55 - 60	73
60 - 65	78
65 - 70	56
70 - 80	104
80 - 90	101
90 - 100	108
100 - 104	

DEPTH (feet)	PID (ppm)
52	0.2
53	0.2
54	0.2
55	*0.1
56	*0.0
57	*0.1
58	*0.1
59	*0.4
60	0.0
61	0.0
62	0.1
63	0.1
64	*0.1
65	*0.5
66	*0.8
67	*0.8
68	*1.6
70	0.0
71	0.3
72	0.8
73	0.7
74	*1.0
75	*1.0
76	*1.6
77	*1.7
78	*0.4
80	1.0
81	0.6
82	3.7
83	3.8
84	0.8
85	1.1
86	1.0
87	1.3
90	1.1
91	1.2
92	1.0
93	1.0
94	0.7
95	*1.1
96	*1.3
97	*1.3
98	*1.4
100	1.3
101	1.4
102	1.8

USCS Classification	SOIL DESCRIPTION
CL	Note: At 49.5 feet dry. Note: At 50 feet trace sand and small to large pebbles.
SW	(58.0 - 60.0) SAND, coarse, few sub-rounded granules, trace small pebbles, loose, trace small cobbles, sub-angular, wet, dense, light gray.
SM	(60.0 - 68.0) SAND, coarse, and silt, few sub-rounded granules, trace silt, trace sub-rounded pebbles, small cobbles, trace clay, hard, dry. Note: At 65 feet very dense, light brown.
SP	(68.0 - 71.0) SAND, coarse, with granules, few small to large pebbles, trace small cobbles, sub-rounded, trace silt with depth, more granules, poorly sorted, wet, light brown.
SW	(71.0 - 79.0) SAND, medium, few coarse sand, trace fine sand, well sorted, wet, very soft, brown. Note: At 78 feet fine sand with some silt.
CH	(79.0 - 81.0) CLAY, some silt and very fine sand, moist, high plasticity, hard, light brown. Note: At 80 to 81 feet coarsening downward to medium sand, with trace silt and clay, low plasticity, well sorted.
SW	(81.0 - 94.0) SAND, medium, trace silt, no plasticity,well sorted, very soft, wet, light brown. Note: At 85 feet sand, fine, with some silt and clay. Note: At 86 feet sand, medium, trace silt.
SP	(94.0 - 120.0) SAND, coarse, few small pebbles to small cobbles, sub-rounded to sub-angular, coarsening downward, trace silt, trace sub-angular granules, loose, poorly sorted, wet, light brown. Note: At 100 feet granules become few with depth. Note: At 102 to 120 feet coarsening downward granules are replaced by small cobbles and sand

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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-14**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	**738.88**
DATE STARTED:	**11/3/2014**	NORTHING:	**623233.265**
DATE COMPLETED:	**11/7/2014**	EASTING:	**1485501.312**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
104–114	116	1.3, 2.0, 1.4, 0.6, 0.4, 0.6, 0.6	SP	decreases with depth.
114–120	144	0.3, 0.4, 0.6, 0.6, 0.6	SP	
120–122		0.7, 0.8	GM	(120.0 - 122.0) SILTY GRANULES and small PEBBLES, few large pebbles, trace coarse sand, sub-rounded, loose, poorly sorted, wet, few cobbles, light brown.
122–130		1.0, 0.5, 0.3, *0.6, *0.4, *0.3	SP	(122.0 - 132.0) SAND, coarse, some granules and medium to fine sand, trace silts, small pebbles, sub-rounded to sub-angular, thin lense to beds of silt content, wet, light brown.
130–132	200	1.0, 0.6		
132–137		0.1, 0.1, 0.0, 0.2, 0.1	OH	(132.0 - 137.0) CLAY, trace fine sand and silt, organic, slight odor of decaying with black sand size striping, very stiff, moist, high plasticity, light brown.
137–140		0.1, 0.1, 0.1	CL / CL	(137.0 - 140.0) CLAY with trace coarse sand, increasing with depth, trace granules and small pebbles, sub-rounded, mostly granitic, moist, medium plasticity, light brown. Note: At 138 feet becomes more rust colored. Clay decrease with depth, some pebbles at 135 to 140 feet.
140–146		0.1, 0.1, 0.2, 0.1, 0.1	SC	(140.0 - 146.0) Clayey SAND, medium, trace silt and coarse sand, trace sub-rounded pebbles, medium stiff, medium plasticity, moist. Note: At 144 feet coarsening downward to few small to large pebbles becomes loose with depth, wet.
145–146	72	0.2		
146–150		0.4, 2.0, 1.0, 1.2	CL	(146.0 - 150.0) Silty CLAY, few small sub-angular pebbles, trace sand, medium plasticity, dry, very hard. End of boring at 150 feet.
150–154				

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

SOIL BORING LOG

BORING NO.: **PSA-15**

TOTAL DEPTH: **100 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	**731.96**
DATE STARTED:	**10/27/2014**	NORTHING:	**623134.376**
DATE COMPLETED:	**10/30/2014**	EASTING:	**1484860.886**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0	VAC TRUCK	1.0	ASPHALT	(0.0 - 0.4) ASPHALT.
2		NM	CONCRETE	(0.4 - 1.5) CONCRETE.
4			SP	(1.5 - 12.0) SAND, medium, with sub-rounded to rounded pebbles, moist, trace silt, poorly graded, brown. Note: At 4 to 8 feet some cobbles and trace boulders.
6		1.1		
8	36	0.2		Note: At 8 feet dry, concrete, no boulders.
10	55	2.5		
		2.0		
12		2.5	SP	(12.0 - 23.0) SAND, fine, little granules, non-plastic, moist, light brown to tan.
14		1.2		
		0.7		
16	53	0.2		Note: At 15 to 18 feet, reddish bands, dry, tan.
		1.1		
18		1.2		
		1.0		
20		1.3		
	60	0.4		
22		3.2		
		4.6		
24		2.0	SP	(23.0 - 30.0) SAND, fine to coarse, with granules, some large pebbles, sub-angular, trace silt, loose, light brown.
		1.0		
26	60	2.6		Note: At 26 feet trace pebbles with granules.
28		1.0		Note: At 28 feet trace silty clay, trace pebbles, small, lense of red.
		1.5		
30	108	0.6	GP	(30.0 - 33.0) GRANULES with medium sand, some silt to fine sand, trace small to large pebbles, wet, loose, poorly sorted, black lens at 1 foot, rest light brown, sub-angular to angular.
32		0.8		
		1.5		
34		1.6	SP	(33.0 - 41.0) SAND, medium, with small to very large pebbles, sub-rounded to angular, poorly sorted, wet, loose, light brown.
		1.2		

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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

ARCADIS

SOIL BORING LOG

BORING NO.: **PSA-15**

TOTAL DEPTH: **100** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Jason Greer**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Chris Kassel**	GROUND ELEVATION:	**731.96**
DATE STARTED:	**10/27/2014**	NORTHING:	**623134.376**
DATE COMPLETED:	**10/30/2014**	EASTING:	**1484860.886**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
35-36		0.7	SP	Note: At 37 feet coarse sand, trace silt, pebbles are dark.
36-38		1.7		
38-39		1.8		
39-40		1.6		
40-41	108	1.3		
41-42		*1.5	CL	(41.0 - 44.0) Silty CLAY, low plasticity, trace sub-rounded granules to small pebbles, low plasticity to medium plasticity, dry, hard, light brown.
42-43		*5.4		
43-44		*5.8		
44-45		*3.3	SM	(44.0 - 46.0) SILT and fine sand, few granules to small pebbles, sub-angular, loose, soft, dry. light gray.
45-46	50	*0.6		
46-47		1.4	SP	(46.0 - 50.0) SAND, coarse, some silt, angular, sub-rounded, wet, light brown.
47-48		1.8		
48-50		1.0		Note: At 48 feet light brown, wet, fewer pebbles at base.
50-51	56	2.9	SP	(50.0 - 51.0) SAND, fine, with granules, trace pebbles, angular, loose, trance medium sand.
51-52		4.5	GW	(51.0 - 53.0) GRANULES, small to medium, sub-angular to sub-rounded, some silt and medium to coarse sand, well sorted, wet, light brown.
52-53		7.6		
53-54		2.6	CL	(53.0 - 57.0) Silty CLAY, little sub-angular granules to medium pebbles, low plasticity, trace sand, dry, loose, light brown.
54-55		2.8		
55-56	64	3.0		Note: At 55 feet light gray.
56-57		*1.8		
57-58		*1.1	SC	(57.0 - 60.0) Clayey SAND, fine, medium plasticity, wet, soft, light brown.
58-59		*0.9		Note: At 58 to 59 feet sand fine to coarse, fining upward.
59-60		*2.9		Note: At 60 feet medium, wet, light gray.
60-61	16	*3.0	CL	(60.0 - 63.0) Silty CLAY, hard to soft, angular, granules, medium plasticity, trace sand, moist to dry, light gray.
61-62		*2.2		
62-63		*1.5		
63-64		*1.4	GP	(63.0 - 64.0) GRANULES and small pebbles, some coarse sand, trace silt, loose, poorly sorted, wet, light gray.
64-65		*1.2	SC	(64.0 - 65.0) SAND, medium, trace silt, low plasticity, trace clay, well sorted, wet, hard, light brown.
65-66		*0.8	SW	(65.0 - 68.0) SAND, coarse, fining downward, few pebbles, trace silt, loose,wet, light brown.
66-67		*0.9		Note: At 66 feet some clay, low plasticity, poorly sorted.
67-68		*0.5		
68-69		0.4	SP	
69-70		0.3		

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ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-15**

TOTAL DEPTH: **100 feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**Chris Kassel**
DATE STARTED:	**10/27/2014**
DATE COMPLETED:	**10/30/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Cascade**
DRILLER:	**Jason Greer**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**731.96**
NORTHING:	**623134.376**
EASTING:	**1484860.886**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
70–76	200	0.4, 0.3, 0.7, 0.5, 0.4, 0.3		SP	(68.0 - 70.0) SAND, coarse, with small pebbles, trace silt, coarsening downward, angular to sub-angular, loose, poorly sorted, wet, light brown. (70.0 - 76.0) SAND, coarse grained with few large pebbles, some granules, rounded to sub-rounded, loose, wet, non-plastic, silty medium sand, poorly sorted, light brown. Note: At 72 feet, coarse grained, some medium sand, trace fine sand and silt, trace pebbles.
76–79		*0.3, *1.1, *1.4		SW	(76.0 - 79.0) SAND, medium, with trace silt, soft to very soft, wet, light gray.
79–82		*1.3, *1.5, *1.2		ML	(79.0 - 82.0) SILT, laminated, stiff, trace fine sand, trace clay, medium plasticity, moist, rapid dilatancy, light gray. Note: At 80 feet silty clay, sub-angular granules, trace sand.
82–84	200	0.2, 1.4		SW	(82.0 - 84.0) SAND, medium, trace coarse sand and fine sand, well sorted, very soft, wet, light brown.
84–90		0.6, *0.7, *1.3, *1.4, *1.1, *1.5		GP	(84.0 - 90.0) GRANULES and pebbles, poorly sorted, some coarse sand, trace silt, fining downward, rounded to sub-angular, wet, light brown.
90–94	108	1.9, 3.3, 3.9, 3.5		SW	(90.0 - 94.0) SAND, coarse, with trace granules small pebbles, some medium sand, sub-round, well sorted, wet, loose, light brown.
94–100		2.4, 1.3, 2.4, 2.4, 2.0		SP	(94.0 - 100.0) SAND, medium, some coarse sand with medium pebbles,sub-angular, trace silt and fine sand, poorly sorted, wet, loose, light brown. End of boring at 100 feet.
100–102					

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-15A**

TOTAL DEPTH: **40** **feet bls**

PROJECT INFORMATION

CLIENT: **RACER Trust**
PROJECT: **Process Sump Area Investigation**
SITE LOCATION: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2014**
LOGGED BY: **Kevin Swiadek**
DATE STARTED: **12/16/2014**
DATE COMPLETED: **12/16/2014**

DRILLING INFORMATION AMSL

DRILLING CO.: **Stock Drilling**
DRILLER: **Austin Goldsmith**
DRILLING METHOD: **Rotosonic**

GROUND ELEVATION: **732.01**
NORTHING: **623139.014**
EASTING: **1484858.408**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0 - 1	VAC TRUCK	NM	CONCRETE	(0.0 - 1.5) CONCRETE.
1 - 2		0.2	SP	(1.5 - 2.0) SAND, medium, few pebbles, rounded, moist, loose, poorly sorted, brown.
2 - 4		0.8	SP	(2.0 - 8.0) SAND, medium, dense, small cobble at base, sub-rounded, poorly sorted, moist, loose, moist, brown coarsening downward.
4 - 6	36	0.3		
6 - 8		0.2		
8 - 9		0.3	SP	(7.0 - 13.0) SAND, fine to medium with granules, some small to very large pebbles, trace silt, sub-rounded, poorly sorted, very loose, light brown.
9 - 10		0.2		
10 - 11	63	0.2		
11 - 12		0.1		
12 - 13		0.1		Note: At 12 to 13 feet dry.
13 - 14		0.2	SP	(13.0 - 14.0) SAND, coarse to medium , some small to large pebbles, trace silt, poorly sorted, moist, very loose, dark brown.
14 - 15		0.2	SP	(14.0 - 24.0) SAND, fine to medium with granules, some small to very large pebbles, trace silt, poorly sorted, sub-rounded, light brown.
15 - 16	120	0.2		
16 - 17		0.2		Note: At 16 to 17 feet more fine sand.
17 - 18		0.1		Note; At 17 to 18 feet more medium sand.
18 - 19		0.1		Note: At 18 to 20 feet some cobbles.
19 - 20		0.1		
20 - 21	36	0.2		
21 - 22		0.2		

Notes:
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NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

SOIL BORING LOG

ARCADIS

BORING NO.: **PSA-15A**

TOTAL DEPTH: **40** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**732.01**
DATE STARTED:	**12/16/2014**	NORTHING:	**623139.014**
DATE COMPLETED:	**12/16/2014**	EASTING:	**1484858.408**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
22		0.2			Note: At 22 to 24 feet trace cobbles.
		0.1		SP	Note: At 23 feet wet.
24		*0.3		SP	(24.0 - 26.0) SAND and granules, some small to large pebbles, poorly sorted, loose, wet, light brown to tan.
		*0.2			
26	42	0.2		SP	(26.0 - 29.0) SAND medium with granules and small to large pebbles, poorly sorted, moist, loose, olive.
		0.2			
28		0.1			Note: At 28 to 29 feet decreasing pebbles and granules, sand becoming more fine, increase silt.
30–34	NM	NM		NO RECOVERY	(29.0 - 35.0) NO RECOVERY.
36		*1.5		SP	(35.0 - 39.0) SAND and granules, some silt, some clay, sub-angular to round, poorly sorted, wet, medium dense, tan.
	43	*1.4			
38		*4.1			Note: At 38 to 39 feet increasing pebble size.
		11.3		CL	(39.0 - 40.0) CLAY and silt with medium pebbles to small cobbles, sub-angular, rapid dilatancy, wet, very stiff, tan. End of boring at 40 feet.
40					
42					
44					

Notes:
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NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

SOIL BORING LOG

ARCADIS

BORING NO.: **PSA-16**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.91**
DATE STARTED:	**12/22/2014**	NORTHING:	**623104.097**
DATE COMPLETED:	**12/28/2014**	EASTING:	**1485234.792**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0	VAC TRUCK	1.0		CONCRETE	(0.0 - 0.5) CONCRETE.
2		1.4		SP	(0.5 - 8.0) SAND, medium, some rounded pebbles, few granules, trace silt and clay, soft, moist, brown.
4		0.7			
6		2.1			
8	79	3.3		SP	(8.0 - 18.0) SAND, fine to medium, and granules, trace silt, some small to large pebbles, sub-angular, poorly sorted, dry, very loose, brown.
10		0.9			
12		0.5			
14		0.6			Note: At 14 to 16 feet increasing pebble size.
16		0.9			
18	87	1.1		SW	(18.0 - 28.0) SAND, fine, trace silt, some small to medium pebbles, dry, very loose, tan.
20		1.0			
22		1.0			
24		0.8			Note: At 24 to 26 feet some small to medium pebbles.
26		1.2			Note: At 27 feet increasing pebble size.
28	130	2.8		CL	(28.0 - 33.5) CLAY, some silt, trace fine sand, some granules to very large pebbles, no diltancy, dry, tan. Note: At 29 feet gray.
30		12.2			
32		*10.5			
34		*3.4		SP	(33.5 - 37.0) SAND with silty clay, some small to medium pebbles, poorly sorted, wet, brown. Note: At 34 to 36 feet decreasing silt and clay.
36		*4.1		CL	(37.0 - 38.0) CLAY, some silt, some small to medium pebbles, no dilatancy, moist, soft, brown.
38	119	1.1		SP	(38.0 - 49.0) SAND with silty clay, medium to coarse, some round small to large pebbles, poorly sorted, wet, brown.
40		1.1			
42		*1.0			
44		*1.2			
46		*1.8			
48		*5.9		CL	(49.0 - 53.0) CLAY, some granules to large pebbles, no dilatancy, dry, hard, dark gray.
50		0.8			

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-16**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**Kevin Swiadek**
DATE STARTED:	**12/22/2014**
DATE COMPLETED:	**12/28/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Stock Drilling**
DRILLER:	**Austin Goldsmith**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.91**
NORTHING:	**623104.097**
EASTING:	**1485234.792**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
52	141				
		*0.7			(53.0 - 54.0) SILT and clay, some fine to medium sand, trace rounded small to medium pebbles, non-plastic, no dilatancy, medium stiff, moist, gray.
54		1.5		ML	(54.0 - 56.0) CLAY, some granules to large pebbles, no dilatancy, dry, hard, dark gray.
56		0.5		CL	(56.0 - 58.0) SILT and clay, some fine to medium sand, trace rounded small to medium pebbles, non-plastic, no dilatancy, medium stiff, moist, gray.
58	109	0.6		ML	
60		0.9		CL	(58.0 - 66.0) CLAY, trace small to medium pebbles, low plasticity, no dilatancy, moist, very stiff, gray.
62		0.9			
64		1.3			
66		*1.2		SP	(66.0 - 68.0) SAND, fine, and granules to very large pebbles, sub-angular to sub-rounded, poorly sorted, loose, dry, brown.
68	81	*0.6		ML	(68.0 - 68.5) Clayey SILT, few small to medium pebbles, medium plasticity, no dilatancy, moist, gray.
70		*0.9		SP	(68.5 - 76.0) SAND, medium to coarse and small to very large pebbles, trace silt, sub-angular, poorly sorted, wet, loose, brown.
72		*0.7			
74		0.6			
76		0.4		SW	(76.0 - 78.0) SAND, fine to medium, trace small pebbles, well sorted, wet, loose, brown.
78	116	0.2		SW	(78.0 - 97.0) SAND, very fine to fine, some silt, well sorted, moist, loose, brown.
80		0.1			
82		0.3			
84		0.3			
86		*0.2			Note: At 86 to 88 feet increase in silt, trace clay.
88	93	0.2			
90		0.3			
92		0.3			
94		0.4			Note: At 94 to 96 feet increase to medium to coarse sand, some granules to large pebbles, some silt, wet.
96		0.3			
97				GC	(97.0 - 98.0) PEBBLES and CLAY, granule to very large pebbles, some silt, some sand, sub-angular to sub-rounded, poorly sorted, wet, medium dense, brown.
98		*NM		NO RECOVERY	(98.0 - 108.0) NO RECOVERY.
100		*NM			
102					

Notes:
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NR: No Recovery
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NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-16**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.91**
DATE STARTED:	**12/22/2014**	NORTHING:	**623104.097**
DATE COMPLETED:	**12/28/2014**	EASTING:	**1485234.792**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
102–104	NM	*NM			NO RECOVERY.
104–106		NM			
106–108		NM			
108–110	41	0.3		SP	(108.0 - 118.0) SAND, medium to very coarse and granules to very large pebbles, poorly sorted, wet, loose, brown.
110–112		0.2			
112–114		*0.2			
114–116		*0.2			
116–118		*0.2			
118–120	62	0.3		CL	(118.0 - 123.0) CLAY and silt, some rounded medium to large pebbles, medium plasticity, slow dilatancy, wet, medium stiff, gray.
120–122		0.1			
122–124		0.1		SP	(123.0 - 128.0) SAND and silt, medium to coarse, some clay, some granules to small cobbles, poorly sorted, wet, medium dense, tan.
124–126		0.1			
126–128		*0.2			
128–130	NM	*0.0		SP	(128.0 - 136.0) SAND, medium to coarse, some silt, some small to very large pebbles, sub-rounded, poorly sorted, wet, very loose, gray.
130–132		*0.0			
132–134		0.1			
134–136		0.0			
136–138		0.0		ML	(136.0 - 137.0) SILT and sand, fine, some clay, moist, medium dense, gray.
				CL	(137.0 - 145.0) CLAY, no dilatancy, dry, very stiff, dark gray.
138–140	151	0.0			
140–142		0.0			
142–144		0.1			
144–146		0.0		SC	(145.0 - 150.0) SAND, very fine, and clay, some silt, medium plastic, moist, stiff.
146–148		0.1			
148–150		*0.1			End of boring at 150 feet.
150–152					

Notes:
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

ARCADIS

SOIL BORING LOG

BORING NO.: **PSA-17**

TOTAL DEPTH: **150 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.84**
DATE STARTED:	**12/17/2014**	NORTHING:	**622959.301**
DATE COMPLETED:	**12/21/2014**	EASTING:	**1485092.839**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION
0–6.5	VAC TRUCK	NM		VAC TRUCK	(0.0 - 6.5) VAC TRUCK.
6.5–8	30	2.4		SP	(6.5 - 23.0) SAND, medium to fine, some very large pebbles to small cobbles, sub-rounded, well sorted, moist, very loose, brown.
8–18	55	0.4, 0.4, 0.1, 0.1, 0.6			Note: At 7.5 to 8 feet increase in granules and small to very large pebbles. Note: At 8 to 10 feet brown, dry. Note: At 10 to 12 feet becomes more fine sand. Note: At 15 feet increase in small to very large pebbles, light brown. Note: At 16 to 18 feet increase in cobbles.
18–28	73	0.4, *0.1, *0.2			Note: At 21 to 23 feet wet, some silt.
		0.3		ML	(23.0 - 25.0) SILT, some trace sand and granules, low plasticity, moist, stiff, brown.
		0.1		CL	(25.0 - 27.0) CLAY some granules and pebbles, low plasticity, dry, hard, gray.
28–38	96			SP	(27.0 - 28.0) SAND, fine, some silt, some granules to large pebble, poorly sorted, moist, loose, gray.
		0.2, 0.7, 1.6, 0.5, 0.6		CL	(28.0 - 40.0) CLAY, some silt and small to large pebbles, dry, hard, gray. Note: At 32 feet decreasing pebble content.
38–48	118	*0.3			
		*0.2, *0.2, *0.3, *0.2		SP	(40.0 - 47.0) SAND, coarse, and granules, trace silt, some small to medium pebbles, sub-rounded, poorly sorted, wet, very loose, brown. Note: At 42 to 44 feet trace cobbles. Note: At 42 to 44 feet trace cobbles. Note: At 46 to 47 feet decrease in cobbles, small to large pebbles.
48–50		0.1, *0.6		ML	(47.0 - 48.0) SILT and clay, medium plasticity, slow dilatancy, moist, very stiff, light brown.
				ML	

Notes:
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*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-17**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
SITE LOCATION:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**		
LOGGED BY:	**Kevin Swiadek**	GROUND ELEVATION:	**738.84**
DATE STARTED:	**12/17/2014**	NORTHING:	**622959.301**
DATE COMPLETED:	**12/21/2014**	EASTING:	**1485092.839**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
52	129	0.2	SW	(48.0 - 51.0) SILT and clay, some fine sand, medium plastic, slow dilatancy, moist, very soft.
54		0.1	CL	(51.0 - 52.0) SAND, fine, well sorted, moist, loose, brown.
56		0.1		(52.0 - 59.5) CLAY, trace silt, trace small to medium pebbles, dry, hard, gray. Note: At 54 to 56 feet increasing silt, very stiff.
58	108	0.2		
60		*1.6	SP	(59.5 - 74.0) SAND, medium to coarse, and granules to large pebbles, some silt, sub-angular, poorly sorted, wet, loose, light brown.
62		*0.2		
64		*0.2		
66		0.1		
68	96	0.5		
70		0.4		
72		0.4		
74		*0.6	ML	(74.0 - 76.0) SILT, trace fine sand, no plasticity, slow dilatancy, wet, soft, dark brown.
76		*1.7	SP	(76.0 - 77.0) SAND, medium, with granules to large pebbles, sub-round, poolry sorted, wet, loose, dark brown.
78	113	*1.3	SP	(77.0 - 83.0) SAND, fine to medium, trace small pebbles, wet, loose, dark brown.
80		0.6		
82		0.4		
84		0.7	ML	(83.0 - 86.0) SILT and clay, medium plastic, slow dilatancy, wet, medium stiff, gray.
86		0.8	SP	(86.0 - 88.0) SAND, coarse, some silt, some granules to medium pebbles, trace cobbles, sub-angular to sub-round, poorly sorted, wet, loose, dark brown.
88	56	0.4	GW	(88.0 - 90.0) PEBBLES, and small cobbles, rounded, well sorted, wet, very loose, multi-color.
90		*0.3	SP	(90.0 - 98.0) SAND, fine to medium, some granules to large pebbles, some silt, poorly sorted, wet, loose, brown.
92		*0.2		
94		*0.2		
96		0.3		
98		0.3	GW	(98.0 - 105.0) PEBBLES, and small cobbles, sub-round to round, well sorted, wet, very loose, multi-color.
100		0.2		
102				

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-17**

TOTAL DEPTH: **150** **feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
SITE LOCATION:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**Kevin Swiadek**
DATE STARTED:	**12/17/2014**
DATE COMPLETED:	**12/21/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Stock Drilling**
DRILLER:	**Austin Goldsmith**
DRILLING METHOD:	**Rotosonic**
GROUND ELEVATION:	**738.84**
NORTHING:	**622959.301**
EASTING:	**1485092.839**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
102–104	28	*0.1	GW	
104–106		*0.3		
106–108		*0.3	SP	(105.0 - 108.0) SAND, fine to very fine, some small to medium pebbles, poorly sorted, wet, loose, gray.
108–110	91	0.1	GW	(108.0 - 109.0) PEBBLES, small to large, some silt, well sorted, wet, loose, gray.
110–112		0.0	SP	(109.0 - 116.0) SAND, fine to very fine, some silt, some small to medium pebbles, poorly sorted, wet, loose, gray.
112–114		0.1		
114–116		0.1		
116–118		0.0	GW	(116.0 - 117.0) PEBBLES, small to very large, some silt, well sorted, wet, loose, brown.
118–120	122	0.2	CL	(117.0 - 122.0) CLAY, trace silt, no dilatancy, moist, very stiff, gray.
120–122		0.1		Note: At 120 to 122 feet hard.
122–124		0.2	WEATHERED BEDROCK	(122.0 - 125.0) BEDROCK, weathered, and clay and silt, gray, fractured, appears dry.
124–126		0.1		
126–128	36	0.1	CL	(125.0 - 127.0) CLAY, some silt, medium plasticity, slow dilatancy, moist, hard, gray.
128–130	89	1.1	WEATHERED BEDROCK	(127.0 - 150.0) BEDROCK, weathered.
130–132		9.8		
132–134		6.0		
134–136		4.9		
136–138		1.4		
138–140	92	6.2		
140–142		0.7		Note: At 140 to 150 feet appears dry.
142–144		1.1		
144–146		0.6		
146–148		1.7		
148–150		4.1		
150–152				End of boring at 150 feet.

Notes:
bls: below land surface
NR: No Recovery
*Indicates sample submitted for laboratory analysis.
NR: No Recovery
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
HK: Hydroknife
AMSL - Above Mean Sea Level

Date: 2/27/2015

SOIL BORING LOG

BORING NO.: **PSA-18**

TOTAL DEPTH: **129 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Alan Blackwood**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/16/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0	Air Knife	1.1		CONCRETE	(0.0 - 0.8) CONCRETE
				SW	(0.8 - 6.0) SAND, fine grained, some granules and small to large pebbles, poorly sorted, trace silt, moist, brown.
2		0.4			Note: From 2 to 6 feet, dry.
4		0.4			
6	38	2.2		SW	(6.0 - 28.0) SAND, very fine to medium, little granules and small to large pebbles, trace small cobbles, angular to round, trace silt, loose, dry, brown.
8		2.6			
	116				Note: From 9 to 19 feet, granules and pebbles increase to some.
10		2.5			
12		2.3			
14		3.2			
16		2.6			
18		5.8			
20	78	5.0			
					Note: From 21 to 22 feet, moist.
22		5.4			Note: From 22 to 25 feet, granules and pebbles decrease to little.
24		6.0			
26					

Notes:
bgs: below ground surface
in.: inch
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-18**

TOTAL DEPTH: **129 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **11/16/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
26		10.2			
28		11.0		ML	(28.0 - 31.0) SILT, little clay, some sand, little granules and small to very large pebbles, angular to round, hard, dry, tan. Note: From 29 to 31 feet, moist.
30		8.5			
32		9.5		GM	(31.0 - 37.0) GRANULES and very coarse SAND, little pebbles and medium to coarse sand, trace cobbles, little silt, angular to round, loose, wet, brown.
34	164	8.6			
36		13.5			
38		*15.3		ML	(37.0 - 40.0) SILT and sand, some granules to large pebbles, angular to round, moist, brown. Note: From 39 to 40 feet, pulverized limestone, hard, dry, grayish brown.
40	79	*13.5		CL	(40.0 - 41.0) CLAY, some silt, some angular to round sand, granules and pebbles, hard, dry, low plasticity, gray.
42		*10.7		SW	(41.0 - 43.0) SAND and granules, some small to very large pebbles, angular to round, loose, trace silt, wet, brown.
44				CL	(43.0 - 44.0) CLAY, some silt, some angular to round sand, granules and pebbles, hard, dry, low plasticity, gray.
		9.6		SW	(44.0 - 46.0) SAND, poorly sorted, medium to very coarse, little granules and small to large pebbles, trace silt, angular to round, loose, wet, brown. Note: From 45.5 to 46 feet, some clay, trace small cobbles.
46	78	20.8		ML	(46.0 - 47.0) SILT, some clay, some sand, little small to very large angular to round pebbles, hard, slightly moist, brown.
48		16.4		SW	(47.0 - 50.0) SAND, granules and pebbles, trace cobbles, angular to round, some clay and silt, moist, yellowish brown.
50		2.1		CL	(50.0 - 54.0) CLAY, some silt, little sand, little small to very large pebbles, trace small cobbles, hard, low plasticity, slightly moist, gray.
52					

Notes:
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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-18**

TOTAL DEPTH: **129 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Alan Blackwood**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/16/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52–54	158	1.6			
54–56		8.0		SW	(54.0 - 57.5) SAND, medium to very coarse, some granules and small pebbles, angular to round, loose, trace silt, wet, brown.
56–58		9.0			Note: From 56 to 57.5 feet, pebbles increase.
58–60		2.7		CL	(57.5 - 59.0) CLAY, some silt, little sand, little small to very large pebbles, trace small cobbles, hard, low plasticity, slightly moist, gray.
	121			SW	(59.0 - 60.0) SAND, medium to very coarse, some granules and small pebbles, angular to round, loose, trace silt, wet, brown.
60–62		4.6		ML	(60.0 - 63.0) SILT, some very fine sand, little angular to round granules, coarse sand and pebbles, little clay, hard, moist, gray.
62–64		4.1		CL	(63.0 - 69.0) CLAY, little silt, little angular to round sand and pebbles, slightly moist, medium plasticity, hard, gray.
64–66		2.0			
66–68		2.7			
68–70		*2.6			
70–72	118	*2.7		SW	(69.0 - 81.0) SAND and granules, medium to very coarse sand, some small to very large pebbles, trace small cobbles, angular to round, loose, trace silt and fine sand, wet, brown.
72–74		*3.1			Note: From 72 to 73 feet, pebbles increase.
74–76		2.7			
76–78		4.5			

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-18**

TOTAL DEPTH: **129 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Alan Blackwood**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/16/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78		5.3			
80		4.4			
81				GW	(81.0 - 83.0) PEBBLES, small to very large, some granules, little medium to very coarse sand, angular to round, trace silt, loose, wet, brown.
82		*1.3			
83				SW	(83.0 - 86.0) SAND, medium to very coarse, and granules, some small to medium pebbles, angular to round, trace silt, loose, wet, brown.
84	113	*2.2			
86		*2.6		SP	(86.0 - 88.0) SAND, medium grained, well sorted, lose, wet, brown.
88		24.7		ML	(88.0 - 89.0) SILT, non-plastic, rapid dilatancy, very stiff, slightly moist, gray.
89				SW	(89.0 - 94.0) SAND, medium to very coarse, trace granules and small to very large pebbles, angular to round, loose, wet, brown.
90		5.5			
92		8.2			
94	130	11.0		GW	(94.0 - 99.0) GRANULES, small to very large pebbles, and medium to very coarse sand, angular to round, trace silt and trace cobbles, loose, wet, brown.
96		*8.8			
98		*11.9			
99				SW	(99.0 - 106.0) SAND, medium to very coarse, little granules, angular to round, loose, poorly sorted, wet, brown.
100		*3.1			
102	27	4.2			
104					

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-18**

TOTAL DEPTH: **129 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Alan Blackwood**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/16/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104		4.7			Note: From 104 to 106 feet, granules increase to some, some small pebbles.
106	76	5.1		GW	(106.0 - 123.5) GRANULES, some medium to very coarse sand, some small to very large pebbles, trace small to large cobbles, angular to round, loose, trace silt, wet, brown.
108		4.5			
110		5.1			
112		4.3			
114	84	3.8			
116		3.0			Note: From 116 to 119 feet, pebbles decrease to little.
118		4.1			
120		5.4			
122		5.8			
124	139	8.4		BEDROCK	(123.5 - 126.0) Weathered BEDROCK, shale, clay, little silt, trace angular pebbles and small cobbles of limestone, medium plasticity, hard, gray.
126		10.0		BEDROCK	(126.0 - 129.0) Weathered BEDROCK, pulverized limestone, some clay, weathered shale, dry, gray.
128		13.4			
130					End of boring at 129 feet.

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-19**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0–1	Air Knife	0.4		CONCRETE	(0.0 - 1.0) CONCRETE.
1–3		0.7		FILL	(1.0 - 3.0) FILL, sand fine to very coarse, some granules and small pebbles, poorly sorted, angualr to round, moist, loose brown.
3–8		0.5, 0.0		FILL	(3.0 - 8.0) FILL, clay, some sand and silt, low plasticity, medium stiff, moist, dark brown. Note: From 5 to 6 feet, silt decreases to little, little gravel. Note: From 6 to 8 feet, trace small to large pebbles, Note: At 8 feet, large cobble.
8–16	56	0.6, 0.3, 0.0, 0.0		SP	(8.0 - 16.0) SAND, fine grained, well sorted, loose, moist, brown. Note: From 9 to 11 feet, some small to very large angular to round pebbles.
16–16.5		0.0		SW	(16.0 - 16.5) SAND, very fine to coarse, poorly sorted, some small to large pebbles, little silt, loose, moist, brown.
16.5–26	182	0.0, 0.3, 1.9, 1.6		SW-SM	(16.5 - 30.0) SAND, fine to very coarse, some granules and small to large pebbles, trace cobbles, little silt, poorly sorted, angular to round, moist to dry, brown.

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-19**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
26–28		1.2		
28–30		2.1		
30–32		0.2	SW	(30.0 - 32.5) SAND, medium to very coarse, some granules, trace pebbles, poorly sorted, angular to round, loose, wet, brown.
32–34		3.0	GW-GM	(32.5 - 34.0) PEBBLES, small to large, some fine to very coarse sand and granules, little silt, poorly sorted, angular to round, loose, wet, brown.
34–36		6.9	SP	(34.0 - 35.0) SAND, very fine to fine, well sorted, trace pebbles, loose, wet, brown.
			SW	(35.0 - 36.0) SAND, medium to very coarse and granules, little pebbles, trace cobbles, poorly sorted, angular to round, loose, wet, brown.
36–38	60	0.6	GW	(36.0 - 37.0) PEBBLES, small to very large and granules, little medium to very coarse sand, angular to round, loose, wet, brown.
			CL	(37.0 - 40.0) CLAY, little silt, little sand, little granules to pebbles, low plasticity, very stiff, moist, gray.
38–40		*0.0		
40–42		*1.4	GW	(40.0 - 41.0) GRANULES and small to large pebbles, some medium to very coarse sand, poorly sorted, angular to round, trace silt, loose, wet, brown.
	48		GW	(41.0 - 52.2) GRANULES and medium to very coarse sand, some small to large pebbles, poorly sorted, angular to round, loose, trace silt, wet, brown.
42–44		*0.7		
44–46		*4.9		
46–48		*6.6		Note: From 46 to 52.2 feet, trace angular to round small to large cobbles.
48–50		*9.3		
50–52	137	*8.7	GW-GM	Note: From 51 to 52.2 feet, silt increases to little.

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-19**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52–53		3.2		CL	(52.2 - 55.5) CLAY, some very fine sand, some silt, trace angular to round pebbles, very stiff, low plasticity, moist, gray.
54–55		5.7			Note: From 54 to 54.5 feet, poorly sorted fine to coarse sand, wet.
55.5–56.5				SP	(55.5 - 56.5) SAND, fine to very coarse, some granules, little small pebbles, poorly sorted, angular to round, loose, wet, gray.
56–57	87	2.8		CL	(56.5 - 65.0) CLAY and SILT, some very fine sand, little angular to round, small to very large pebbles, low plasticity, hard, dry, gray.
58–59		7.7			Note: At 57 to 57.6 feet layer of very fine sand.
60–61		5.8			Note: At 60 to 61 feet sand increases.
62–63		8.9			
64–65		*9.7			Note: From 64.7 to 65 feet, orange.
66–67	120	*7.3		GW	(65.0 - 71.0) GRANULES and small to very large pebbles, some medium to very coarse sand, trace silt, trace cobbles, angular to round, poorly sorted, loose, wet, brown.
68–69		*7.0			
70–71		8.8			
72–73		2.4		SW	(71.0 - 78.2) SAND, medium to very coarse, little granules and small to large pebbles, poorly sorted, angular to round, loose wet, brown to orangish brown.
74–75		2.9			
76–77		3.2			Note: From 75.2 to 78.2 feet, granules and pebbles increase to some.
78					

Notes:
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-19**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78–79	204	*3.5		CL	(78.2 - 78.7) Varied CLAY with alternating laminations of silt, moist, stiff, gray.
				SP	(78.7 - 85.0) SAND, medium, well sorted, loose, wet, brown to gray.
79–80		*3.4			
81–82		*3.3			
84–86		*3.6		ML	(85.0 - 86.0) SILT and very fine sand, rapid dilatancy, non-plastic, very stiff, moist, gray.
86–88	176	2.4		SP	(86.0 - 94.0) SAND, medium grained, well sorted, loose, wet, brown.
88–90		3.2			
90–92		3.9			
92–94		4.2			
94–96		*4.7		ML	(94.0 - 95.0) SILT, rapid dilatancy, non-plastic, stiff, moist, brown.
				SW	(95.0 - 97.0) SAND, poorly sorted, medium to very coarse, trace granules and pebbles, angular to round, loose, wet, brown.
96–98		*5.8		GW	(97.0 - 99.0) PEBBLES, small to very large, little granules and sand, little small to large cobbles, trace silt, loose, poorly sorted, angular to round, wet, brown.
98–100		*5.7		GW	(99.0 - 116.0) GRANULES and small to large pebbles, some medium to very coarse sand, trace cobbles, trace silt, angular to round, poorly sorted, loose, wet, brown.
100–102		*6.5			Note: From 101 to 116 feet, little sand.
102–104		7.9			

Notes:
bgs: below ground surface
in.: inch
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-19**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104–106	116	3.8			
106–108		3.6			
108–110		5.1			
110–112		*6.6			
112–114		*6.2			
114–116		*8.5			
116–118	190	*4.7		GW	(116.0 - 124.0) GRANULES and small to very large pebbles, some medium to very coarse sand, trace cobbles, poorly sorted, angular to round, trace silt, loose, gray.
118–120		*3.0			
120–122		*3.7		GW-GM	Note: From 120 to 124 feet, silt increasing too little, cobbles increase to little.
122–124		*9.2			Note: From 123 to 124 feet, moist, little clay.
124–126		7.9		CL	(124.0 - 129.5) CLAY, some sand, little angular to round granules, and small to very large pebbles, little silt, very stiff, medium plasticity, moist, orangish brown.
126–128		10.3			
128–130		*8.3		CL	(129.5 - 131.0) CLAY, little silt, very stiff, medium plasticity, moist, trace angular granules

Notes:
bgs: below ground surface
in.: inch
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NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-19**

TOTAL DEPTH: **150 feet bgs**

PROJECT INFORMATION

CLIENT: **RACER Trust**

SITE LOCATION: **Process Sump Area Invstigation**

CITY, STATE: **Moraine, Ohio**

PROJECT NUMBER: **OH000294.2015**

LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**

DRILLER: **Corey Preston**

DRILLING METHOD: **Roto Sonic**

DATE STARTED: **10/01/2015**

DATE COMPLETED: **11/03/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
130		*6.7			and small pebbles of shale and limestone, blue-gray with orange and brown, horizontal laminations.
131	24			CL	(131.0 - 134.0) CLAY and cobbles, some granules and small to very large pebbles, angular to round, very stiff, moist, gray. Note: At 134 feet, pulverized limestone.
132		*22.8			
134	68	NM		BEDROCK	(134.0 - 150.0) Weathered BEDROCK, limestone, fractured 0.5 to 2 inch thick core pieces, little clay, gray.
136		NM			
138		NM			
140		NM			
142		NM			
144		NM			
146		NM			
148		NM			
150					End of boring at 150 feet.
152					

Notes:

bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-20**

TOTAL DEPTH: **146 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **OH000294.2015**
PROJECT NUMBER: **OH001171.0002**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01//2015**
DATE COMPLETED: **10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0	Air Knife	10.0		ASPHALT	(0.0 - 0.3) ASPHALT.
				GC	(0.3 - 3.0) PEBBLES, small to large, some fine to very coarse sand, angular to round, little silt and clay, moist, dark brown, slight odor.
2		1.6			
				CL	(3.0 - 4.0) CLAY, some sand, little silt, little pebbles, low plasticity, stiff, moist, dark brown.
4		NM		SW	(4.0 - 8.0) SAND, fine to very coarse and small to very large pebbles and small cobbles, poorly sorted, angular to round, loose slightly moist, brown. Note: Unable to collect sample for field screening.
6	120	4.1			
8		1.6		SW	(8.0 - 16.0) SAND, fine to coarse, little granules and pebbles, trace small to large cobbles, poorly sorted, angular to round, loose, slightly moist, brown.
10		2.8			
12		3.0			
14		4.3			
16	67	2.6		SW	(16.0 - 24.0) SAND, medium to coarse, granules and small to very large pebbles, little small to large cobbles, poorly sorted, angular to round, trace silt, moist, brown.
18		1.6			
20		3.0			
22		3.9			
24		3.8		GW	(24.0 - 29.0) GRANULES and small to very large pebbles, little small to large cobbles, little sand, poorly sorted, angular to round, trace to little silt, moist, brown.

Notes:
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in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-20**

TOTAL DEPTH: **146 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**OH000294.2015**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH001171.0002**	DATE STARTED:	**10/01//2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)
26 - 28	128	4.2
28 - 30		4.7
30 - 32		4.1
32 - 34		3.5
34 - 36		*3.2
36 - 38	65	*1.2
38 - 40		*1.2
40 - 42		*1.1
41 - 50	198	
42 - 44		*3.0
44 - 46		*2.8
46 - 48		*3.2
48 - 50		2.7

USCS Classification	SOIL DESCRIPTION
GW	Note: From 26 to 29 feet, sand increases to some.
ML	(29.0 - 30.0) SILT and sand, some angular to round granules and pebbles, trace small cobbles, moist, non-plastic, brown.
SW	(30.0 - 32.5) SAND, medium to very coarse, poorly sorted, little granules, trace pebbles and small cobbles, angular to round, wet, brown.
GW	(32.5 - 34.0) GRANULES, some coarse to very coarse sand, little small to very large pebbles, angular to round loose, wet, brown.
SP	(34.0 - 34.5) SAND, very fine grading to medium, loose, wet, brown.
SW	(34.5 - 35.5) SAND, medium to very coarse, poorly sorted, some granules, little pebbles, angular to round, loose, brown.
COBBLE	(35.5 - 36.0) COBBLE small to large, some sand, granules and pebbles, angular to round, loose, wet, orangish brown.
SW	(36.0 - 41.0) SAND, medium to very coarse, some granules and pebbles, trace small to large cobbles, poorly sorted, angular to round, loose, wet, brown.
SW	(41.0 - 42.5) SAND, medium to very coarse, and granules, some small to large pebbles, poorly sorted, angular to round, loose, wet, brown.
GW	(42.5 - 47.0) GRANULES and small to very large pebbles, trace small to large cobbles, poorly sorted, loose, angular to round, wet, brown.
CL	(47.0 - 49.5) CLAY, some silt, little very fine sand, little small to very large angular to round pebbles and granules, low plasticity, very stiff, moist, gray.
SW	(49.5 - 54.0) Very fine SAND, little silt and clay, little granules and pebbles, angular to

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SOIL BORING LOG

BORING NO.: **PSA-20**

TOTAL DEPTH: **146 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**OH000294.2015**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH001171.0002**	DATE STARTED:	**10/01//2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
50		2.4			round, dense, moist, gray.
52		2.3			
54		2.2		CL	(54.0 - 62.5) CLAY, some silt, little very fine sand, little small to very large angular to round pebbles, and granules, low plasticity, very stiff, moist, gray.
56		2.6			
58		3.2			
60	150	3.1			
62		*3.6		SW	(62.5 - 66.0) SAND, medium to very coarse, little granules and pebbles, poorly sorted, angular to round, loose, wet, brown.
64		*3.8			
66		2.7		SW	(66.0 - 68.0) SAND, poorly sorted, fine to very coarse, trace granules, angular to round, loose, wet gray.
68	61	2.8		GW	(68.0 - 68.7) PEBBLES, small to large, some granules, little sand, angular to round, poorly sorted, loose, brown.
				SW	(68.7 - 76.0) SAND, medium to very coarse, some granules and small to very large pebbles, trace small cobbles, poorly sorted, angular to round, loose, wet, brown.
70		3.2			
72		5.9			Note: From 72 to 74 feet, granules and pebbles increase.
74		7.2			

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ppm: parts per million
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ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-20**
TOTAL DEPTH: **146 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**OH000294.2015**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH001171.0002**	DATE STARTED:	**10/01//2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
76–77	214	6.9		SP	(76.0 - 79.0) SAND, medium, trace medium to large pebbles, well sorted, loose, wet, brown.
78–79		7.6			Note: From 79 to 79.3 feet, orange laminations.
79–81		7.3		SP	(79.0 - 81.0) SAND, very fine, well sorted, loose, wet, gray.
81–90		8.3, 7.9		SP	(81.0 - 90.0) SAND, medium grained, well sorted, loose, wet, brown.
86–90	146	2.6, 2.5			Note: At 89 feet, large round cobble.
90–100		2.0, 2.2, 2.2, 2.9, 2.8		SW	(90.0 - 101.0) SAND, medium to very coarse, poorly sorted, loose, some granules, trace small to large pebbles, angular to round, wet, brown.

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-20**

TOTAL DEPTH: **146 feet bgs**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
SITE LOCATION:	**Process Sump Area Invstigation**
CITY, STATE:	**OH000294.2015**
PROJECT NUMBER:	**OH001171.0002**
LOGGED BY:	**Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.:	**TerraSonic**
DRILLER:	**Corey Preston**
DRILLING METHOD:	**Roto Sonic**
DATE STARTED:	**10/01//2015**
DATE COMPLETED:	**10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
100		3.1			
101–112	182	2.0, 2.4, 2.3, 2.3, 2.5		GW	(101.0 - 112.0) GRANULES and medium to very coarse sand, little small to very large pebbles, trace cobbles, poorly sorted, angular to round, loose, wet, brown. Note: From 111 to 112 feet, pebbles increase to some.
112–117		*2.8, *3.0, *4.4		GW	(112.0 - 117.0) PEBBLES, small to very large, some granules and medium to coarse sand, little cobbles, poorly sorted, angular to round, loose, trace silt, wet, brown.
117–120.5	138	4.5		GW	(117.0 - 120.5) GRANULES, some small to very large pebbles, some fine to very coarse sand, trace cobbles, poorly sorted, angular to round, loose, trace silt, wet, brown.
120.5–121		5.7		GW-GM	(120.5 - 121.0) PEBBLES, small to very large, some granules and medium to coarse sand, little cobbles, poorly sorted, angular to round, loose, trace silt, wet, brown.
121–126		5.6, 5.4		GW-GM	(121.0 - 126.0) GRANULES, medium to very coarse sand, and small to very large pebbles, little small to large cobbles, angular to round, poorly sorted, loose, little silt, wet, brown.

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-20**

TOTAL DEPTH: **146 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **OH000294.2015**
PROJECT NUMBER: **OH001171.0002**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01//2015**
DATE COMPLETED: **10/24/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
126–128		5.9		SW-SM	(126.0 - 138.0) SAND, medium to very coarse, and granules, little small to very large pebbles, trace cobbles, poorly sorted, angular to round, loose, trace silt, wet, brown
128–130		4.5			
130–132		4.6			Note: From 131 to 138 feet, silt increases to little, very moist.
132–134		6.4			Note: From 133 to 138 feet, granules decrease to some, pebbles decrease to trace.
134–136		13.2			
136–138		14.7			
138–140	194	16.4		SC	(136.0 - 138.0) SILT and CLAY, increase to some, orangish brown.
				CH	(138.0 - 139.0) CLAY, trace silt, very stiff, high plasticity, no dilatancy, moist, brown orange and gray horizontal laminations.
140–142		10.6		BEDROCK	(139.0 - 146.0) Weathered BEDROCK, - shale, clay and limestone, clay has little silt, medium plasticity, dry, blue-gray.
142–144		17.4			
144–146		18.8			
146					End of boring at 146 feet.

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-21**

TOTAL DEPTH: **150 feet bgs**

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0-2	Air Knife	1.3		CONCRETE	(0.0 - 0.8) CONCRETE.
				FILL	(0.8 - 1.5) FILL, gravel.
2-4		0.1		CL	(1.5 - 8.0) CLAY, some sand and silt, low plasticity, soft, moist, dark brown.
4-6		0.3			Note: From 4 to 6 feet, trace gravel, small to medium round pebbles.
6-8	18	13.1			Note: From 7 to 8 feet, dry.
8-10	127	3.9		SW	(8.0 - 10.0) SAND, medium to very coarse, poorly sorted, little granules and pebbles, loose, slightly moist, brown.
10-12		4.2		GW	(10.0 - 23.0) GRAMI:ES and small to very large pebbles, trace cobbles, some medium to very coarse sand, trace silt, poorly sorted, loose, angular to round, slightly moist, brown.
12-14		4.9			
14-16		3.3			
16-18		2.5			
18-20	85	1.4			Note: From 18 to 23 feet, moist.
20-22		1.5			
22-24		2.5		SW	(23.0 - 38.0) SAND, medium to very coarse, some granules, little small to very large pebbles, trace silt, loose, poorly sorted, angular to round, dry, brown.
24-26		2.6			

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-21**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
26–28		3.9			
28–30	67	0.3			Note: From 28 to 38 feet, pebbles increase to some, trace small to large cobbles, wet.
30–32		0.1			
32–34		*0.2			
34–36		*0.0			
36–38		*0.0			
38–40	107	0.3		GW	(38.0 - 49.0) PEBBLES, small to very large, and granules, little to some medium to very coarse sand, trace small cobbles, poorly sorted, angular to round, trace silt, loose, wet, brown.
40–42		1.7			
42–44		*2.8			
44–46		*2.2			
46–48		*3.2			Note: From 46 ato 48 feet, silt increases to some.
48–50	95	1.2		CL	(49.0 - 50.0) CLAY, some silt, little sand, trace small to medium pebbles, hard, low plasticity, dry, orangish brown to gray.
50–52		1.3		SM	(50.0 - 54.0) SAND, very fine, and SILT, little clay, little small to very large pebbles, angular to round, stiff, moist, gray.

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-21**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Alan Blackwood**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52–54		2.2			Note: From 52.3 to 52.7 feet, stiff layer of medium to very coarse sand, poorly sorted, wet, brown.
54–56	60	4.0		SW	(54.0 - 56.0) SAND, fine to very coarse, poorly sorted, little granules and small to large pebbles, trace small cobbles, loose, wet, brown.
56–58		6.5		SW	(56.0 - 56.5) SAND, very fine to fine, loose, trace angular small pebbles and angular to round granules, very moist, grayish brown.
				ML	(56.5 - 60.0) SILT and very fine sand, little granules and small angular to round pebbles, trace clay, low plasticity, very stiff, dry, gray.
58–60		7.1			Note: From 58 to 60 feet, moist to dry. Note:From 59 to 60 feet, hard.
60–62		4.6		CL	(60.0 - 66.5) CLAY, some silt, some very fine sand, trace to little granules and small to very large pebbles, angular to round, slightly moist, hard, gray.
62–64	147	6.7			
64–66		5.7			
66–68		*5.8		CH	(66.5 - 67.0) CLAY, little silt, very stiff, moist, high plasticity, gray, orange, brown.
				SW	(67.0 - 68.0) SAND, fine to very coarse, and granules and small to very large pebbles, little silt, poorly sorted, angular to round, moist, brown.
68–70		*8.6		GW	(68.0 - 73.0) GRANULES and small to very large pebbles, some medium to very coarse sand, trace silt, angular to round, loose, wet, brown.
70–72	34	*8.1			
72–74		*7.8		SW	(73.0 - 78.0) SAND, medium to very coarse, and granules, little small to very large pebbles, trace small cobbles, poorly sorted, loose, angular to round, wet, brown.
74–76	89	6.5			Note: From 75 to 76 feet, pebbles increase to some.
76–78		8.0			

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SOIL BORING LOG

BORING NO.: **PSA-21**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78	122	4.9		SW	(78.0 - 85.0) SAND, medium to very coarse, little granules and pebbles, poorly sorted, angular to round, loose, wet, brown.
80		6.2			Note: From 80 to 85 feet, trace granules and pebbles.
82		6.4			
84		13.2			
85				SP	(85.0 - 97.0) SAND, medium grained, well sorted, trace angular to round pebbles, wet, brown.
86		27.2			
87				SP-SM	Note: From 87 to 88 feet, some very fine sand, little silt.
88	93	17.6			
90		20.3			
92		20.6			
93.5	170				
94		0.0			
95					Note: From 95 to 95.6 feet, little silt and very fine sand.
96		0.0			
97				SW	(97.0 - 98.0) SAND, medium to very coarse, little granules, trace small to medium pebbles, angular to round, loose, wet, brown.
98	NM	0.0		GW	(98.0 - 106.0) GRANULES and medium to very coarse sand, some small to very large pebbles, trace small cobbles, trace silt, angular to round, loose, wet brown.
100		0.0			Note: From 100.8 to 101.3 feet, some very fine sand and silt.
102		*0.0			Note: From 102 to 106 feet, sand decreases to some.
104					

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-21**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104		*0.0			
106		*0.0		GW	(106.0 - 116.0) GRANULES and small to very large pebbles, little sand, trace silt, trace small cobbles, angular to round, loose, wet, brown. Note: From 107.5 to 108 feet, silt increases to little.
108		1.5			
110		1.6			
112	124	1.8			
114		2.2			
116		*2.1		SW	(116.0 - 117.0) SAND, medium to very coarse, poorly sorted, little granules, angular to round, wet, brown.
				GW	(117.0 - 118.0) GRANULES and small to very large pebbles, little sand, trace silt, trace small cobbles, angular to round, loose, wet, brown.
118		*2.4		GW	(118.0 - 123.0) GRANULES and pebbles, medium to very coarse sand, angular to round, loose, wet brown.
120	18	*2.3			
122		*2.2		GW	(123.0 - 130.0) GRANULES, small to very large pebbles, some granules, some medium to very coarse sand, trace silt, trace cobbles, loose, angular to round, wet, brown.
124		2.1			
126		1.7			
128	120	1.3			
130					

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ppm: parts per million
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-21**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Alan Blackwood**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **11/08/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
130		1.6		SW	(130.0 - 134.0) SAND, medium to very coarse, little granules, little small to very large pebbles, trace silt, trace cobbles, angular to round, loose, wet, brown.
132		*2.0			
134	81	*2.4		GW	(134.0 - 135.0) GRANULES and medium to very coarse sand, some small pebbles, angular to round, loose, wet, brown.
				GW	(135.0 - 136.5) Pebbles, small to very large and GRANULES, little medium to very coarse sand, little small cobbles, trace silt, angular to round, loose, brown.
136		*1.2		SW	(136.5 - 140.7) SAND, medium to very coarse, and granules, little small to medium pebbles, angular to round, loose, trace silt, wet, orangish brown. Note: From 138 to 140.7 feet, brown.
138	143	0.9			
140		*1.3		SP	(140.7 - 143.0) SAND, very fine coarsing downward to fine, loose, wet, gray and brown.
142		*1.2		SP	(143.0 - 147.0) SAND, medium grained, well sorted, loose, wet, brown and gray.
144		*1.1			
146		*1.0		CL	(147.0 - 150.0) CLAY, little sand, some silt, low plasticity, stiff, moist, black. Note: From 148 to 150 feet, sand content increase with depth to some at 148 feet to clay and sand from 149 to 150 feet.
148		*0.9			
150					End of boring at 150 feet.
152					

Notes:
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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-22**
TOTAL DEPTH: **135 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge/Kevin Swiadek**	DATE COMPLETED:	**12/20/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0–2	Air Knife	0.8		CONCRETE	(0.0 - 1.0) CONCRETE.
				SP	(1.0 - 5.0) SAND, some fine to very coarse, some granules and small to large pebbles, poorly sorted, angular to round, very loose, trace silt, dry, brown.
2–4		1.0			
4–6		1.0		SP	(5.0 - 10.0) SAND, poorly sorted, fine to coarse, trace small to large pebbles and granules, angular to round, dry, very loose. Note: From 6 to 10 feet trace cobbles, granules and pebbles increase to little.
6–8	41	1.2			
8–10		*1.4			
10–12	84	1.0		SP	(10.0 - 25.0) SAND, GRANULES, and PEBBLES, fine to very coarse, small to very large pebbles, trace cobbles, angular to round, very loose, dry, brown. Note: From 20 to 25 feet pebbles decrease to little.
12–14		2.1			
14–16		1.7			
16–18		2.1			
18–20		1.9			
20–22	52	4.6			
22–24		5.8			
24–26		*9.5		SP	(25.0 - 30.0) SAND, fine to very coarse, granules and small to very large pebbles, little cobbles, trace silt, angular to round, very loose, dry, tan.
26–28		3.0			

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ft: feet
*Indicates sample submitted for laboratory analysis.

Date: 2/10/2016

SOIL BORING LOG

BORING NO.: **PSA-22**

TOTAL DEPTH: **135 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge/Kevin Swiadek**	DATE COMPLETED:	**12/20/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
28–30		5.5			
30–32	131	1.6		CL	(30.0 - 33.0) CLAY, little silt, trace angular to round sand, trace granules and pebbles, medium plasticity, moist, grayish brown.
32–34		2.1		CL	(33.0 - 38.0) CLAY, little silt, some sand and angular to round granules and pebbles, dry, low plasticity, hard, grayish brown.
34–36		1.5			
36–38		*1.7			Note: From 37 to 38 feet stiff.
38–40		1.4		PEBBLES	(38.0 - 40.0) PEBBLES, small to very large, some granules, little medium to very coarse sand, trace cobbles, trace silt, angular to round, loose, wet, yellowish brown.
40–42	165	0.9		CL	(40.0 - 45.0) CLAY, little silt, trace angular to round sand, granules and pebbles, medium plasticity, moist, grayish brown.
42–44		1.9			
44–46		2.1		CL	(45.0 - 59.0) CLAY, little silt, some sand and angular to round granules and pebbles, dry, low plasticity, hard, grayish brown.
46–48		1.8			
48–50		1.8			
50–52	83	1.3			
52–54		1.2			
54–56		0.8			

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ppm: parts per million
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-22**

TOTAL DEPTH: **135 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge/Kevin Swiadek**	DATE COMPLETED:	**12/20/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
56–60	62	2.2		
		79.6	SP	(59.0 - 60.3) SAND, medium to very coarse, trace fine sand, granules and small pebbles, angular to round, loose, moist, brown.
60–65	72	*1.4	CL	(60.3 - 60.8) CLAY, little silt, some sand, granules and pebbles, low plasticity, moist, hard, grayish brown.
			SP	(60.8 - 62.3) SAND, medium to very coarse, trace fine sand, granules and pebbles, angular to round, loose, wet, brown.
		*1.0	CL	(62.3 - 64.8) CLAY, little silt, little angular to round sand, granules and pebbles, medium plasticity, hard, moist, grayish brown.
		*1.2	SP	(64.8 - 65.0) SAND, very fine, little silt, well sorted, wet, loose, grayish brown.
65–75	120	*38.7	SP	(65.0 - 71.5) SAND, medium to very coarse, trace granules and pebbles, poorly sorted, angular to round, very loose, wet, grayish brown.
		*24.0		
		8.2		
		1.9	ML	(71.5 - 73.3) SILT, some very fine sand, rapid dilatancy, very stiff, non-plastic, moist, brown.
		2.6	CL	(73.3 - 74.7) CLAY, little silt, trace sand and angular to round pebbles, hard, medium plasticity, moist, gray.
			SP	(74.7 - 75.0) SAND, medium to very coarse, trace granules and pebbles, poorly sorted, angular to round, very loose, wet, orange.
75–80	94	2.2	PEBBLES	(75.0 - 77.0) PEBBLES, small to very large, some granules, little sand, trace silt, trace cobbles, angular to round, very loose, brown.
		1.6	SP	(77.0 - 79.3) SAND, medium to very coarse, little granules and pebbles, angular to round, very loose, wet, brown.
			SP	(79.3 - 80.0) SAND, medium, well sorted, very loose, wet, orangish brown.
80–84	106	*1.7	PEBBLES	(80.0 - 82.0) PEBBLES and GRANULES, some medium to very coarse sand, angular to round, very loose, wet, brown.
		*3.1	SP	(82.0 - 83.0) SAND, medium to very coarse, with pebbles, some granules, trace cobbles, angular to round, very loose, wet, brown.
			SP	

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-22**

TOTAL DEPTH: **135 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge/Kevin Swiadek**	DATE COMPLETED:	**12/20/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
84		*5.0		SP	(83.0 - 85.0) SAND, medium to coarse, little granules and pebbles, angular to round, very loose, wet, brown. Note: From 84.5 to 85 feet pebbles and granules increase to some.
86	34	4.0			(85.0 - 86.0) SAND, medium to very coarse, poorly sorted, very loose, angular to round, wet, brown.
88		4.5		PEBBLES	(86.0 - 92.0) GRANUELS and SAND, medium to very coarse sand, trace small to large pebbles, angular to round, very loose, wet, brown. Note: From 88 to 90 feet some small pebbles, trace silt.
90		3.6			
92	124	4.2		PEBBLES	(92.0 - 100.0) PEBBLES, GRANULES and SAND, medium sand to very large pebbles, trace cobbles, angular to round, very loose, wet, brown.
94		*3.5			
96		*2.5			Note: At 96 to 99 feet trace silt.
98		*2.7			
100	88	1.1		SP	(100.0 - 103.0) SAND, fine to medium, trace silt, well sorted, wet, very loose to loose, gray.
102		0.3		PEBBLES	(103.0 - 108.0) GRANULES and small to large PEBBLES, trace coarse sand, well sorted, very loose, wet, gray.
104		1.4			
106	121	0.8			
108		1.3		SP	(108.0 - 109.0) SAND, fine to medium, trace silt, well sorted, wet, very loose, gray.
				SP	(109.0 - 110.0) SAND, medium, some silt and clay, well sorted, medium dense, moist, brown.
110		*1.1		SP	(110.0 - 115.0) SAND and small to large PEBBLES, medium to coarse, poorly sorted, wet, loose, brown.
112					

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-22**

TOTAL DEPTH: **135 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge/Kevin Swiadek**	DATE COMPLETED:	**12/20/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
112–115	43	*0.9			
		*1.3			
115–117	85	1.1		SP	(115.0 - 117.0) SAND, medium to coarse, trace silt, well sorted, wet, loose, brown.
117–120		0.6		SP	(117.0 - 120.0) SAND, fine, some silt, well sorted, loose to medium dense, wet, brown.
120–122	104	1.5		ML	(120.0 - 122.0) SILT, some fine sand, no plasticity, rapid dilatancy, wet, soft, tan.
122–129		2.1		SP	(122.0 - 129.0) SAND, fine to medium, trace small pebbles, well sorted, wet, loose, tan.
		*1.2			Note: From 124 to 126 increase in pebble size.
		*1.6			Note: From 126 to 128 some small granules, wet.
		*0.2			
129–135	54	0.2		CL	(129.0 - 135.0) CLAY, medium plasticity, no dilatancy, dry, hard, brown. Note: From 130 to 132 trace small pebbles
		0.3			
		0.2			
135					End of boring at 135 feet.

Notes:
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-23**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**

SITE LOCATION: **Process Sump Area Invstigation**

CITY, STATE: **Moraine, Ohio**

PROJECT NUMBER: **OH000294.2015**

LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**

DRILLER: **Corey Preston**

DRILLING METHOD: **Roto Sonic**

DATE STARTED: **10/01/2015**

DATE COMPLETED: **12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0	Air Knife	2.4		CONCRETE	(0.0 - 0.9) CONCRETE.
				SP	(0.9 - 2.0) SAND, fine sand to large pebbles, trace silt, angular to round, poorly sorted, loose, dry, brown.
2		1.9		CL	(2.0 - 4.0) CLAY, some sand, little silt trace granules and pebbles, stiff, low plasticity, moist, dark brown.
4		1.2		SP	(4.0 - 6.0) SAND, fine to coarse, little granules to large pebbles, angular to round, poorly sorted, loose, dry, brown.
6	37	2.1		SP	(6.0 - 12.5) SAND, fine to very coarse and CLAY, little round to angular granules and pebbles, trace small cobbles, moist, brown.
8		4.6			
10	90	3.2			
12		6.3		SP	(12.5 - 29.0) SAND, very fine to fine, little medium to very coarse sand, little small to very large pebbles, angular to round, trace silt, loose, dry, brown and tan.
14		9.7			
16		14.5			Note: From 16 to 19 feet granules and pebbles increase to some.
18		13.8			Note: From 19 to 29 feet some granules and pebbles, trace cobbles.
20	82	7.4			
22		11.0			
24		10.3			
26					

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ppm: parts per million
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-23**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
26–27		18.5			
28–29		22.5			
29–39	105			GW	(29.0 - 49.0) GRANULES and small to large PEBBLES, some medium to very coarse sand, trace silt, trace cobbles, angular to round, loose, wet, brown.
30–31		6.0			
32–33		14.2			
34–35		21.3			
36–37		32.9			Note: From 36 to 39 feet, sand increases to some.
38–39		40.4			
39–49	136				Note: From 39 to 49 feet silt increases to little.
40–41		169			Note: Negative result for NAPL test from 40 to 42 feet.
42–43		153			Note: Negative result for NAPL test from 42 to 44 feet.
44–45		127			Note: Negative result for NAPL test from 44 to 46 feet.
46–47		80.1			
48–49		90.4			
49.0–51.0				GW	(49.0 - 51.0) GRANULES and small to very large PEBBLES, little medium to very coarse sand, little silt, trace small to large cobbles, angular to round, loose, wet, brown.
50–51		521			
51.0–56.0				SP	(51.0 - 56.0) SAND, very fine to medium, some granules and small to medium pebbles, little

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-23**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52	142	949			silt, angular to round, dense, moist, gray. Note: Negative result for NAPL test from 50 to 52 feet. Note: Negative result for NAPL test from 52 to 54 feet. Note: Negative result for NAPL test from 54 to 56 feet. Note: From 54 to 55 feet, trace fines, wet.
54		858			
56		763		SP	(56.0 - 58.0) SAND, medium to very coarse, little granules, trace pebbles, angular to round, loose, wet, gray, slight odor. Note: Negative result for NAPL test from 56 to 58 feet.
58		587		GW	(58.0 - 59.0) GRANULES, some fine sand, some small to medium pebbles, angular to round, loose, wet, brown. Note: Negative result for NAPL test from 58 to 60 feet.
59	143			SP	(59.0 - 62.0) SAND, medium to very coarse, some granules, little small pebbles, angular to round, loose, wet, brown. Note: Negative result for NAPL test from 60 to 62 feet.
60		193			
62		166		SP	(62.0 - 67.0) SAND, very fine to fine, well sorted, coarsing downward to medium from 66 to 67 feet, loose, wet, orange at 62 to 62.5 feet to brown from 62.5 to 67 feet. Note: Negative result for NAPL test from 62 to 64 feet. Note: Negative result for NAPL test from 64 to 66 feet.
64		123			
66		271			
67				CL	(67.0 - 69.4) CLAY, little silt, little sand, trace granules and small to large angular to round pebbles, moist, hard, medium plasticity, gray. Note: Negative result for NAPL test from 66 to 68 feet.
68		140			
69.4	132			GW	(69.4 - 74.0) GRANULES and small to very large PEBBLES, some medium to very coarse sand, trace cobbles, angular to round, loose, wet, brown. Note: Negative result for NAPL test from 68 to 70 feet.
70		*3.3			
72		*3.6			
74		*9.6		SP	(74.0 - 75.6) SAND, medium to very coarse, little granules, trace small to very large pebbles angular to round, loose, wet, brown.
75.6				SP	(75.6 - 78.0) SAND, very fine to fine, well sorted, trace silt, loose, wet, brown to gray. Note: From 77 to 78 feet silt increases to some.
76		89.1			
78					

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-23**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**10/01/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78		26.8		SP	Note: From 77.8 to 78 feet orange. (78.0 - 79.0) SAND, medium, well sorted, very loose, wet, orangish brown to brown.
80		34.8		GW	(79.0 - 82.0) GRANULES and small to very large PEBBLES, some medium to very coarse sand, trace silt, trace cobbles, angular to round, loose, wet, brown.
82		30.8		SP	(82.0 - 88.0) SAND, medium, well sorted, loose, moist, brown.
84	122	40.3			
86		27.3			
88		*19.8		SP	(88.0 - 89.0) SAND, very fine, well sorted, dense, little silt, moist, gray.
				SP	(89.0 - 90.0) SAND, medium to very coarse, angular to round, poorly sorted, loose, wet, brown.
90		*5.5		GW	(90.0 - 90.5) GRANULES and small pebbles, angular to round, loose, wet, brown.
	59			PEBBLES	(90.5 - 91.3) PEBBLES, small to very large, little granules, trace sand and cobbles, trace silt, angular to round, loose, wet, brown.
92		*5.9		SP	(91.3 - 93.5) SAND, medium to very coarse, and GRANULES, little small to very large pebbles, trace cobbles, angular to round, loose, wet, brown.
94				PEBBLES	(93.5 - 94.0) PEBBLES, small to very large, and GRANULES, some sand, trace small cobbles, trace silt, angular to round, loose, wet, brown.
		52.7		SP	(94.0 - 97.0) SAND, medium, well sorted, very loose, wet, brown.
96	43	55.1			
98		55.8		PEBBLES	(97.0 - 101.0) PEBBLES, small to very large and granules, some medium to very coarse sand, trace silt, angular to round, loose, wet, brown. Note: From 99 to 101 feet trace small cobbles.
100		1.4			
102				GW	(101.0 - 102.5) GRANULES and small PEBBLES, some medium to very coarse sand, angular to round, loose, wet, brown.
		*1.3		PEBBLES	(102.5 - 104.5) PEBBLES, small to very large, some granules, some medium to very coarse sand, trace cobbles, trace silt, angular to round, loose, wet, brown.
104	116				

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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-23**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104		*2.2		GW	(104.5 - 107.0) GRANULES, some small pebbles and medium to very coarse sand, trace silt, trace cobbles, angular to round, loose, wet, brown.
106		*1.0			
108		*2.5		PEBBLES	(107.0 - 117.0) PEBBLES, small to very large, some granules, some medium to very coarse sand, trace cobbles, trace silt, angular to round, loose, wet, brown.
110		4.6			
112		0.9			
114	102	0.7			
116		1.2			
118		*1.0		SP	(117.0 - 119.0) SAND, medium to very coarse, some granules, some small to large pebbles, very loose, angular to round, wet, brown.
120		*2.8		PEBBLES	(119.0 - 121.0) PEBBLES, small to very large, some granules, some medium to very coarse sand, trace cobbles, trace silt, angular to round, loose, wet, brown.
122	78	*2.9		PEBBLES	(121.0 - 122.5) PEBBLES, small to very large, some granules and sand, little small cobbles, trace silt, wet, loose, brown.
124		5.4		GW	(122.5 - 129.0) GRANULES and small to large PEBBLES, some medium to very coarse sand, trace cobbles, trace silt, angular to round, loose, wet, brown.
126	62	5.1			
128		7.7			
130				SP	(129.0 - 136.0) SAND, medium to very coarse, some granules and small to very large

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SOIL BORING LOG

BORING NO.: **PSA-23**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **10/01/2015**
DATE COMPLETED: **12/10/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
130–132	136	2.9			pebbles, trace cobbles, loose, angular to round, wet, tan and gray.
132–133		3.1			
134–135		*3.3			
136–137		*3.7		PEBBLES	(136.0 - 139.5) PEBBLES, small to very large, and GRANULES, some fine to very coarse sand, little silt, angular to round, loose, wet, brown. Note: From 137 to 138 feet medium dense, tan.
138–139		*4.6			
140–141	123	4.4		CL	(139.0 - 150.0) CLAY, little silt, some angular to round sand, granules and small to large pebbles, very stiff, medium plasticity, moist, orange brown to gray with olive gray from 140 to 148 feet.
142–143		3.8			
144–145		0.0			Note: From 144 to 150 feet granules and pebbles decrease to trace.
146–147		0.1			
148–149		0.6			
150					End of boring at 150 feet.

Notes:
bgs: below ground surface
in.: inch
*Indicates sample submitted for laboratory analysis.
NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 3/9/2016

SOIL BORING LOG

BORING NO.: **PSA-24**

TOTAL DEPTH: **150 feet bgs**

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0–2	Air Knife	0.7	ASPHALT	(0.0 - 0.5) ASPHALT.
			CONCRETE	(0.5 - 1.3) CONCRETE.
			SW	(1.3 - 1.8) SAND, fine to very coarse, some small to very large pebbles, poorly sorted, angular to round, trace silt, slightly moist, brown.
2–4		0.8	CL	(1.8 - 2.5) CLAY, little sand, trace silt, medium plasticity, very stiff, moist, brown.
			SW-SC	(2.5 - 4.0) SAND, fine to very coarse, and granules, and small to large pebbles, poorly sorted, angular to round, little silt and clay, loose, moist, brown.
4–6		0.5	SW	(4.0 - 16.0) SAND, poorly sorted, fine to coarse, some granules to large pebbles, angular to round, loose, moist, brown. Note: From 6 to 16 feet, trace silt, trace cobbles, slightly moist.
6–8	108	1.7		
8–10		4.1		
10–12		1.9		
12–14		2.0		
14–16		2.5		
16–18	59	2.0	GW	(16.0 - 26.0) GRANULES and PEBBLES, some sand, trace cobbles, poorly sorted, angular to round, loose, trace silt, slightly moist.
18–20		2.6		
20–22		2.0		
22–24		4.6		
24–26		*11.9		

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 3/9/2016

SOIL BORING LOG

BORING NO.:	**PSA-24**
TOTAL DEPTH:	**150 feet bgs**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
SITE LOCATION:	**Process Sump Area Invstigation**
CITY, STATE:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2015**
LOGGED BY:	**Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.:	**TerraSonic**
DRILLER:	**Corey Preston**
DRILLING METHOD:	**Roto Sonic**
DATE STARTED:	**09/30/2015**
DATE COMPLETED:	**10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
26	106	*5.4		GW	(26.0 - 33.0) GRANULES and PEBBLES, little sand, trace cobbles, poorly sorted, loose, angular to round, trace silt, wet, brown.
28		*5.1			
30		*10.2			
32		7.2		SW-SM	(33.0 - 46.0) SAND and granules, some pebbles, trace cobbles, loose poorly sorted, angular to round, trace silt, wet, brown.
34		10.7			
36	123	68.3			
38		124			Note: Negative result for NAPL test from 38 to 40 feet.
40		*38.8		SW-SC	Note: From 40 to 40.3 feet, some clay.
42		*77.9			
44		*50.5			
46	150	19.9		CL	(46.0 - 62.5) CLAY, little sand, little silt, little small to very large angular to round pebbles, very stiff, dry, low plasticity, gray.
48		20.9			
50		8.9			
52					

Notes:
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-24**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52		8.1			
54		5.3			
56		1.4			
57					Note: From 57 to 58 feet sand, granules, and pebbles increase to some.
58		2.6			
60	107	2.2			
62		6.3		SW	(62.5 - 72.0) SAND, medium to very coarse and granules, some pebbles, small to very large, trace cobbles, poorly sorted, loose, angular to round, trace silt, wet, brown.
64		2.8			
66		2.1			
67					Note: From 67 to 71 feet, trace pebbles.
68	62	3.3			
70		3.7			
72		3.6		SP	(72.0 - 73.5) SAND, medium grained, grading to very fine, loose, wet, orangish brown to gray.
74	85			ML	(73.5 - 75.0) SILT, rapid dilatancy, non-plastic, very stiff, moist, gray.
75		11.8		SP	(75.0 - 75.6) SAND, very fine, well sorted, moist, loose, gray.
76		6.4		SP	(75.6 - 79.6) SAND, medium grained, well sorted, loose, wet, brown.
78					

Notes:
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ppm: parts per million
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-24**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78–80	110	15.0			
79.6–80				ML	(79.6 - 80.0) SILT, rapid dilatancy, non-plastic, very stiff, wet, gray.
80–82		3.7		SW	(80.0 - 86.0) SAND, medium to very coarse, some granules and pebbles, round to angular, trace sub-angular to round cobbles, trace silt, loose, poorly sorted, wet, brown.
82–84		3.1			
84–86		*2.9			
86–88	95	1.4		SW	(86.0 - 90.0) SAND, medium to very coarse, some granules, trace pebbles, poorly sorted, angular to round, loose, wet, brown.
88–90		1.8			
90–92		2.4		GW	(90.0 - 92.0) GRANULES and PEBBLES, some medium to coarse sand, trace cobbles, poorly sorted, loose, angular to round, trace silt, brown, wet.
92–94		1.9		SW	(92.0 - 96.0) SAND, medium to very coarse, some granules, trace pebbles and cobbles, poorly sorted, angular to round, loose, wet, brown.
94–96		1.0			Note: From 94 to 96 feet, granules and pebbles increase to some, cobbles increase to little, trace silt.
96–98	60	*0.6		SW	(96.0 - 98.5) SAND, medium to very coarse, poorly sorted, angular to round, loose, wet, brown.
98–100		*0.7		GW	(98.5 - 100.0) GRANULES, some coarse to very coarse sand, angular to round, trace pebbles, loose, wet, brown.
100–102		1.9		GW	(100.0 - 102.0) PEBBLES, small to large, little granules, little medium to very coarse sand, poorly sorted, angular to round, loose, trace silt, wet, brown.
102–104		0.1		GW	(102.0 - 106.0) GRANULES and small to large pebbles, little medium to very coarse sand, poorly sorted, angular to round, trace silt, wet, brown.

Notes:
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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-24**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104	168	0.1			
106		0.6		SW	(106.0 - 107.0) SAND, poorly sorted, medium to very coarse, loose, wet, brown.
				SW	(107.0 - 113.0) SAND, medium to very coarse, little pebbles and granules, trace small cobbles, angular to round, loose, wet, brown.
108		0.3			
110		0.5			
112		0.5			
				GW	(113.0 - 116.0) GRANULES and small to very large pebbles, little coarse sand, trace small cobbles, poorly sorted, angular to round, loose, trace silt, wet, brown.
114		0.6			
116	110	3.4		GW	(116.0 - 117.0) GRANULES, some coarse to very coarse sand, trace silt and small pebbles, poorly sorted, angular to round, loose, wet, brown.
				GW	(117.0 - 120.0) PEBBLES and coarse to very coarse sand, some cobbles, little granules, trace silt, poorly sorted, loose, angular to round, wet, brown.
118		8.4			
120		8.7		SW	(120.0 - 125.0) SAND and granules, little small to large pebbles, trace small cobbles, poorly sorted, angular to round, loose, wet, brown.
122		7.7			
124		7.0			Note: From 124 to 125 feet, little granules and pebbles.
				GW	(125.0 - 126.0) PEBBLES, small to large, some granules, little medium to very coarse sand, trace silt, poorly sorted, angular to round, loose, wet, brown.
126	69	*3.8		SW	(126.0 - 131.5) SAND, medium to very coarse, some granules and pebbles, trace silt and cobbles, angular to round, poorly sorted, loose, wet, brown.
128		*3.2			Note: From 129 to 131 feet, silt increases.
130					

Notes:
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-24**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **10/19/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
130		*4.3			
132	76	4.2		CL	(131.5 - 138.5) CLAY, little silt, little round to angular granules and pebbles, little sand, low plasticity, very stiff, no dilatancy, slightly moist, brown from 131.5 to 133 feet gray from 133 to 136 feet.
134		5.0			Note: From 133.5 to 133.7 feet, layer of fine sand, loose, wet, gray.
136	136	5.5			Note: From 135.5 to 135.8 feet, layer of medium sand, little round to angular granules and pebbles, loose wet, gray. Note: From 136 to 138.5 feet, pebbles increase, dark gray.
138		7.2		CH	(138.5 - 146.0) CLAY, some sand, trace round to angular pebbles, high plasticity, very stiff, moist, dark gray.
140		7.2			Note: At 141 feet color changes to blue gray with orangish brown mottling.
142		6.5			
144		6.3			
146	42	4.3		SW	(146.0 - 150.0) SAND, medium to coarse, some clay, little angular to round granules and pebbles, moist, very stiff, brown, trace blue gray.
148		*2.5			
150					End of boring at 150 feet.

Notes:
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NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-25**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**

SITE LOCATION: **Process Sump Area Invstigation**

CITY, STATE: **Moraine, Ohio**

PROJECT NUMBER: **OH000294.2015**

LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**

DRILLER: **Corey Preston**

DRILLING METHOD: **Roto Sonic**

DATE STARTED: **09/30/2015**

DATE COMPLETED: **10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0–2	Air Knife	0.6		ASPHALT	(0.0 - 0.8) ASPHALT.
				CONCRETE	(0.8 - 1.6) CONCRETE.
2–4		0.7		SW	(1.6 - 3.0) SAND, some granules and pebbles, poorly sorted, fine sand to small cobbles, angular to round, sand sub-round to round, loose, trace silt, slightly moist, brown.
				CL	(3.0 - 5.0) CLAY, some sand, trace granules and pebbles, and silt, medium plasticity, very stiff, moist, brown.
4–6		0.9		SW	(5.0 - 6.0) SAND fine to very coarse, some granules to small cobbles, poorly sorted, angular to round sand, sub-round to round gravel, loose, slightly moist, brown.
6–8	82	2.2		GW	(6.0 - 26.0) PEBBLES, granules, poorly sorted, fine sand to large cobbles, angular to round, trace silt, loose, moist, brown.
8–10		2.5			
10–12		3.8			
12–14		3.0			
14–16		2.9			
16–18	58	2.5			
18–20		1.9		GW-GC	Note: From 18 to 20 feet, little clay.
20–22		1.8			
22–24		2.1			
24–26		*2.7			Note: At 24 feet, wet.

Notes:

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ppm: parts per million
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ft: feet
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SOIL BORING LOG

BORING NO.: **PSA-25**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
26		*1.7		SM	(26.0 - 27.5) SAND fine to very coarse, and silt, some granules and pebbles, angular to round, very moist to wet, brown.
28	41	*4.0		GW	(27.5 - 31.0) GRANULES and PBBLES, some medium to coarse sand, trace silt, tracesmall cobbles, angular to round, poorly sorted, wet, brown.
30		5.4			
32		6.5		GW	(31.0 - 33.0) GRANULES and medium to very coarse sand, poorly sorted, angular to round, little pebbles, loose, wet, brown.
34	44	5.4		GW	(33.0 - 35.2) GRANULES, some medium to coarse sand, trace silt, trace cobbles, angular to round, poorly sorted, wet, brown.
36		4.4		GW	(35.2 - 40.5) GRANULES and sand, poorly sorted, medium to very coarse sand, angular to round, little pebble size gravel, loose, wet, tan to gray. Note: From 36 to 40.5 feet, trace cobbles, gray. Note: From 37.5 to 38.5 feet, small to large pebbles increase to some.
38		3.2			
40	113	5.3		GW	(40.5 - 43.0) GRANULES and small to large pebbles, some medium sand, trace silt, poorly sorted, angular to round, loose, tan, wet.
42		10.4		SW	(43.0 - 45.0) SAND medium to coarse, some granules, poorly sorted, trace pebbles and cobbles, angular to round, loose, wet, brown.
44		6.0		GW	(45.0 - 51.5) GRANULES and small to large pebbles, some medium to very coarse sand, poorly sorted, trace cobbles, angular to round, loose, trace silt, wet, tan. Note: From 47 to 51.5 feet, gray.
46		*11.1			
48		*9.1			
50	123	*3.5			Note: From 50.5 to 51.5 feet, orangish brown.
52				ML	(51.5 - 52.0) SILT, non-plastic, rapid dilatancy, moist, stiff, gray.

Notes:
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ppm: parts per million
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-25**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
52		0.3		SP	(52.0 - 52.5) SAND, very fine, well sorted, moist, loose, gray.
54		0.3		CL	(52.5 - 66.0) CLAY, little silt, little sand, little granules to medium pebbles, hard, low plasticity, dry, gray.
56		4.6			
58		11.0			
60	154	9.3			
62		16.2			
64		3.5			
66		*3.7		GW	(66.0 - 72.0) GRANULES and pebbles, some coarse to very coarse sand, trace silt, poorly sorted, loose, angular to round, wet, brown. Note: At 67, 68 and 71 feet, small to medium cobbles.
68		*13.0			
70	109	*5.0			
72		3.2		SP	(72.0 - 75.0) SAND, fine grained, trace pebbles and plant material, well sorted, loose, wet, orangish brown and gray.
74		4.4		SP	(75.0 - 76.0) SAND, very fine grained, well sorted, trace silt, trace plant material, loose, wet, very fine horizontal laminations, gray.
76		2.3		SP	(76.0 - 78.6) Fine SAND, well sorted, trace granules and pebbles, angular to round, loose wet, brown.
78					

Notes:
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ft: feet

SOIL BORING LOG

BORING NO.: **PSA-25**

TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **TerraSonic**
DRILLER: **Corey Preston**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **09/30/2015**
DATE COMPLETED: **10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
78–79	95	1.1		CL	(78.6 - 79.1) CLAY, little silt, medium plasticity, soft, moist, grayish brown.
79–81		*1.5		SP	(79.1 - 83.5) Medium SAND, well sorted, wet, loose.
81–83		*2.0			Note: From 82.5 to 83.5 feet, some granules and pebbles, trace silt.
83–85		*1.4		GW	(83.5 - 94.5) GRANULES and small to large pebbles, angular to round, poorly sorted, some medium to very coarse sand, loose, wet, brown.
85–87	102	3.2			Note: From 86 to 94.5 feet, trace silt.
87–89		3.4			Note: From 88 to 94.5 feet, trace cobbles.
89–91		3.8			
91–93		4.3			
93–95		4.3		SW	(94.5 - 96.5) SAND, poorly sorted, medium grained to very coarse, trace granules and pebbles, angular to round, loose, wet, brown.
95–97	73	*2.8		GW	(96.5 - 102.0) GRANULES, some small to very large pebbles, little small cobbles, little medium to very coarse sand, poorly sorted, angular to round, wet, trace silt, brown.
97–99		*2.3			
99–101		*3.4			
101–103		0.6		SW	(102.0 - 103.0) SAND, poorly sorted, medium to very coarse, trace granules and small pebbles, angular to round, wet, brown.
103–104				GW	(103.0 - 103.5) GRANULES, some medium to coarse sand, trace pebbles, loose, angular to round, wet, brown.

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-25**
TOTAL DEPTH: **150 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
104	116	0.3		GW	(103.5 - 104.5) PEBBLES, small to large, poorly sorted, little granules, trace coarse to very coarse sand, loose, trace silt, wet, brown.
				SP	(104.5 - 106.0) SAND, poorly sorted, medium to very coarse, some granules, little pebbles, trace cobbles, trace silt, angular to round, wet, loose, brown
106		0.5		GW	(106.0 - 108.5) GRANULES grading to small cobbles, little coarse to very coarse sand, angular to round loose, brown.
108		0.4		GW	(108.5 - 109.5) GRANULES and pebbles, some medium to very coarse sand, poorly sorted, loose, angular to round, trace silt, trace cobbles, wet, brown.
110		0.0		SW	(109.5 - 111.5) SAND, poorly sorted, medium to very coarse, little granules and pebbles, loose, angular to round, wet, brown.
112		0.2		SP	(111.5 - 112.2) SAND, medium grained, well sorted, trace pebbles, angular to round, wet, brown.
				GW	(112.2 - 114.0) GRANULES, some coarse to very coarse sand, little small to large pebbles, angular to round, loose, wet, brown.
114		0.8		SW	(114.0 - 119.0) SAND, poorly sorted, fine to coarse, some granules and pebbles, trace cobbles, trace silt, angular to round, loose, wet, brown.
116	128	1.1			
118		1.6			
				SW	(119.0 - 123.0) SAND, poooryl sorted, medium to coarse, trace granules and pebbles, trace cobbles, angular to round, loose, wet, brown.
120		1.8			
122		2.1			
				SC	(123.0 - 130.0) SAND, fine to coarse, and pebbles, trace cobbles, poorly sorted, angular to round, little silt and clay, wet, brown. Note: From 124.5 to 125 feet, clay content increases to some and color changes to orangish brown. Note: From 126 to 126.5 feet , and 129.5 to 130 feet, clay content increases to some.
124		*2.8			
126	73	*0.1			
128		*0.0			
130					(130.0 - 130.6) CLAY, some granules and pebbles, little sand, low plasticity, very stiff,

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in.: inch
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NM: Not Measured
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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 12/14/2015

SOIL BORING LOG

BORING NO.: **PSA-25**

TOTAL DEPTH: **150 feet bgs**

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**TerraSonic**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Corey Preston**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**09/30/2015**
LOGGED BY:	**Kari Eldridge**	DATE COMPLETED:	**10/11/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
130		*0.0		CL	moist, brown to orangish brown.
				CL	(130.6 - 131.4) CLAY, little silt, medium plasticity, very stiff, slightly moist, blue-gray.
132	78	1.4		CL	(131.4 - 134.0) CLAY and SAND, some granules and pebbles, trace cobbles, low plasticity, moist, very stiff, brown and gray. Note: 0.5 to 1 inch thick layers of gray wet granules every 2-3 inches throughout.
134		0.5		GW	(134.0 - 141.0) GRANULES and pebbles, little sand, trace silt, trace cobbles, loose, wet, brown.
136		1.9			
138		1.7			
140	123	1.5			
142		1.6		ML	(141.0 - 143.0) SILT, non-plastic, rapid dilatancy, moist, very stiff, with pockets of fine to medium sand, wet, loose, gray and dark brown.
144		1.5		CH	(143.0 - 146.0) CLAY, trace silt, high plasticity, no dilatancy, moist, very stiff, black. Note: From 145 to 146 feet, little sand.
146		1.2		CL	(146.0 - 147.0) CLAY, some sand, little silt, little granules and pebbles, medium to low plasticity, very stiff, moist, gray and orangish brown.
148	79	*0.8		CL	(147.0 - 149.5) CLAY and SAND, some granules and pebbles, low plasticity, very stiff, moist, gray and orangish brown. Note: From 149 to 149.5 feet, granules and pebbles decrease to trace, moist.
150				CL	(149.5 - 150.0) CLAY, little silt, medium plasticity, trace cobbles, very stiff, slightly moist, blue-gray and orangish-brown. End of boring at 150 feet.
152					

Notes:
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NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-26**

TOTAL DEPTH: **55 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball/Mike Patrick**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**12/22/2015**
LOGGED BY:	**Kevin Swiadek**	DATE COMPLETED:	**12/28/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0–2	Air Knife	1.8	ASPHALT	(0.0 - 0.5) ASPHALT.
			CONCRETE	(0.5 - 1.5) CONCRETE.
2–4		0.5	SP	(1.5 - 2.0) SAND, medium to coarse, few small to large pebbles, poorly sorted, dry, loose, dark brown.
4–6	50	0.7	SP	(2.0 - 4.0) SAND, fine, well sorted, moist, very loose, light brown to tan.
6–8		0.2	SP	(4.0 - 6.0) SAND, some clay, medium to coarse, few small pebbles, poorly sorted, moist, dark brown.
			CL	(6.0 - 7.0) CLAY, some silt, trace small pebbles, medium plasticity, slow dilatancy, moist, soft to medium stiff, brown.
8–10		0.6	SP	(7.0 - 8.0) SAND, some clay, some silt, few small pebbles, poorly sorted, medium dense, moist, brown.
10–12	109	0.4	SP	(8.0 - 28.5) SAND, medium to coarse, few granules and small to large pebbles, poorly sorted, moist, loose, brown.
12–14		0.8		Note: From 12 to 20 feet fine to medium, dry, brown.
14–16		4.7		
16–18		1.4		
18–20		3.7		
20–22	68	1.4		Note: From 20 to 28.5 feet fine sand, dry, brown.
22–24		0.8		
24–26		1.2		
26–28		1.2		
28–30		*1.0	PEBBLES	(28.5 - 35.0) GRANULES and PEBBLES, some silt, poorly sorted, wet, loose, brown.
30–32		*0.0		

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ppm: parts per million
PID: Photo-ionization Detector
ft: feet

SOIL BORING LOG

BORING NO.: **PSA-26**

TOTAL DEPTH: **55** **feet bgs**

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kevin Swiadek**

DRILLING INFORMATION

DRILLING CO.: **Cascade**
DRILLER: **Ron Ball/Mike Patrick**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **12/22/2015**
DATE COMPLETED: **12/28/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
32–35	35	*0.0			
		*0.0			
35–36	104			CL	(35.0 - 36.0) CLAY, some few small to large pebbles, non-plastic, no dilatancy, dry, very stiff, gray.
36–38		*0.0		PEBBLES	(36.0 - 38.0) GRANULES and PEBBLES, some sand, some silt, poorly sorted, wet, loose, brown.
38–39		*0.0		ML	(38.0 - 39.0) SILT, some fine sand, medium plasticity, rapid dilatancy, wet, loose, gray.
39–40				CL	(39.0 - 40.0) CLAY, some few small to large pebbles, non-plastic, no dilatancy, dry, very stiff, gray.
40–45	46	*0.2		PEBBLES	(40.0 - 45.0) GRANULES and PEBBLES, some silt, poorly sorted, wet, very loose, brown.
		*0.0			
		*0.0			
45–46	68			CL	(45.0 - 46.0) CLAY, some small pebbles, non-plastisc, no dilatancy, dry, very stiff, gray.
46–50		0.0		ML	(46.0 - 50.0) SILT and CLAY, some fine sand, slow dilatancy, moist, soft to medium stiff, gray.
		*0.0			Note: From 48 to 50 feet gray, moist, increase in fine sand.
50–55	45	0.0		CL	(50.0 - 55.0) CLAY, few small to medium pebbles, non-plastic, no dilatancy, dry, hard, gray.
		0.0			
		0.0			
55					End of boring at 55 feet.

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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

Date: 2/10/2016

SOIL BORING LOG

BORING NO.: **PSA-27**

TOTAL DEPTH: **65 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**12/10/2015**
LOGGED BY:	**Kevin Swiadek/Kari Eldridge**	DATE COMPLETED:	**12/17/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
0–1	Air Knife	0.0	CONCRETE	(0.0 - 1.0) CONCRETE.
1–2			SP	(1.0 - 6.0) SAND, medium to coarse, few small to large pebbles, poorly sorted, dry, loose, dark brown.
2–4		1.9		
4–6		0.0		Note: From 4 to 6 feet decrease in pebbles.
6–8	38	5.0	SP	(6.0 - 19.0) SAND, fine to coarse, some granules, little small to very large pebbles, trace silt, angular to round, very loose, dry, brown.
8–10		6.2		
10–12	100	4.2		Note: From 10 to 19 feet trace cobbles.
12–14		9.6		
14–16		6.4		Note: From 14 to 17 feet granules increase to some.
16–18		4.2		Note: From 17 to 18 feet granules and pebbles increase to some, moist, orangish brown.
18–20		3.9	PEBBLES	(19.0 - 20.0) PEBBLES, small to very large, some granules, little fine to medium sand, trace cobbles, trace silt, angular to round, very loose, dry, brown.
20–22	145	2.5	SP	(20.0 - 21.0) SAND, medium to very coarse, some granules, little small to large pebbles, trace to little silt, angular to round, loose, moist, orangish brown.
22–24		2.6	CL	(21.0 - 34.0) CLAY, little silt, little angular to round granules and large pebbles, trace sand, hard, slightly moist, medium plasticity, grayish brown.
24–26		2.6		
26–28		2.1		
28–30		2.4		
30–32		2.6		
32–34		2.7		

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USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-27**
TOTAL DEPTH: **65 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kevin Swiadek/Kari Eldridge**

DRILLING INFORMATION

DRILLING CO.: **Cascade**
DRILLER: **Ron Ball**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **12/10/2015**
DATE COMPLETED: **12/17/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
34–36	117	*3.1	SP	(34.0 - 40.0) SAND, medium to very coarse, and GRANULES, some small to very large pebbles, trace cobbles, trace silt, angular to round, very loose, wet, brown.
36–38		*2.1		
38–40		*2.2		
40–42	128	2.1	PEBBLES	(40.0 - 42.5) GRANULES and PEBBLES, small to very large, some sand, trace cobbles, angular to round, very loose, trace silt, wet, grayish brown.
42–44		2.0	CL	(42.5 - 45.0) CLAY, some sand, granules and pebbles, low plasticity, hard, moist, brown.
44–46		*1.9	PEBBLES	(45.0 - 50.0) GRANULES and PEBBLES, small to very large, some sand, trace cobbles, angular to round, very loose, trace silt, wet, grayish brown.
46–48		*2.0		
48–50		*1.9		
50–52	117	3.1	PEBBLES	(50.0 - 56.0) PEBBLES, small to very large, and GRANULES, some sand, trace silt, trace cobbles, angular to round, loose, wet, grayish brown. Note: From 53 to 55 feet orangish brown. Note: From 55 to 56 feet gray.
52–54		3.8		
54–56		*3.5		
56–58		*1.2	SP	(56.0 - 56.8) SAND, very fine, little silt and clay, little angular to round granules and pebbles, dense, moist, gray.
			SP	(56.8 - 57.3) SAND, fine to very coarse, little granules, trace pebbles, angular to round, loose, wet, gray.
58–60		*1.6	SP	(57.3 - 62.5) SAND, very fine to fine, little silt and clay, trace granules and pebbles, dense, moist, grayish brown. Note: From 58.8 to 59 feet layer of saturated coarse sand.
60–62	94	1.9		
62–64		2.1	CL	(62.5 - 65.0) CLAY, little silt, little sand, little angular to round granules and pebbles, hard, low to medium plasticity, grayish brown.
64–65		1.6		End of boring at 65 feet.

Notes:
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NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

SOIL BORING LOG

BORING NO.: **PSA-28**

TOTAL DEPTH: **60 feet bgs**

ARCADIS

PROJECT INFORMATION

CLIENT: **RACER Trust**
SITE LOCATION: **Process Sump Area Invstigation**
CITY, STATE: **Moraine, Ohio**
PROJECT NUMBER: **OH000294.2015**
LOGGED BY: **Kevin Swiadek**

DRILLING INFORMATION

DRILLING CO.: **Cascade**
DRILLER: **Ron Ball**
DRILLING METHOD: **Roto Sonic**
DATE STARTED: **12/21/2015**
DATE COMPLETED: **12/22/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbol	USCS Classification	SOIL DESCRIPTION
0–1	Air Knife	0.0		CONCRETE	(0.0 - 1.0) CONCRETE.
1–10	Air Knife (0–6); 36 (6–10)	0.0, 0.0, 0.1, 0.0		SP	(1.0 - 10.0) SAND, medium to coarse, few small to large pebbles, poorly sorted, dry, loose, brown. Note: From 4 to 6 feet dry, increase in cobbles, trace clay. Note: At 9 feet large rock in core barrel prevented large sample volume.
10–20	92	0.0, 0.0, 0.6, 5.8, 1.1		SP	(10.0 - 20.0) SAND and GRAVEL, some small to large pebbles, poorly sorted, dry, loose, tan to brown. Note: From 17 to 17.5 feet fine sand.
20–30	68	0.0, 0.0, 0.0, 0.0, 0.0		SP	(20.0 - 30.0) SAND, fine, trace silt, well sorted, dry, loose to medium dense, brown.
30–34	58	0.0, 0.0		SP	(30.0 - 34.0) SAND and GRAVEL, some small to large pebbles, poorly sorted, very loose, wet, brown. Note: From 32 to 34 feet trace pebbles.

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NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet
*Indicates sample submitted for laboratory analysis.

Date: 2/10/2016

SOIL BORING LOG

BORING NO.: **PSA-28**

TOTAL DEPTH: **60 feet bgs**

ARCADIS

PROJECT INFORMATION		DRILLING INFORMATION	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Cascade**
SITE LOCATION:	**Process Sump Area Invstigation**	DRILLER:	**Ron Ball**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Roto Sonic**
PROJECT NUMBER:	**OH000294.2015**	DATE STARTED:	**12/21/2015**
LOGGED BY:	**Kevin Swiadek**	DATE COMPLETED:	**12/22/2015**

DEPTH (feet)	Recovery (inches)	PID (ppm)	USCS Classification	SOIL DESCRIPTION
34		*0.0	SP	(34.0 - 35.0) SAND, fine to medium, well sorted, loose, wet, brown.
36	60	*0.0	SP	(35.0 - 36.0) SAND, coarse and granules, trace small pebbles, poorly sorted, loose, wet, brown.
			PEBBLES	(36.0 - 38.0) GRANULES and PEBBLES, small to large, some sand, trace silt, poorly sorted, loose, wet, brown.
38		*0.0	SP	(38.0 - 40.0) SAND, coarse and granules, trace small pebbles, poorly sorted, loose, wet, brown.
40	80	0.0	SP	(40.0 - 44.0) SAND and granules, coarse, some small to large pebbles, poorly sorted, wet, loose, brown.
42		0.0		
44		0.0	PEBBLES	(44.0 - 45.0) GRANULES and PEBBLES, trace sand and silt, poorly sorted, wet, loose, brown.
46		0.0	SP	(45.0 - 51.5) SAND and GRANULES, coarse, trace small to medium pebbles, poorly sorted, wet, loose, brown.
48		0.0		
50	78	*0.3		Note: From 50 to 51.5 feet increase in pebbles.
52		*0.1	PEBBLES	(51.5 - 54.0) GRANULES and PEBBLES, large, trace silt, poorly sorted, wet, loose, brown.
54		*0.7	CL	(54.0 - 54.5) CLAY, non-plastic, no dilatancy, dry, hard, gray.
	96		SP	(54.5 - 55.0) SAND, medium to coarse, some silt, well sorted, loose, brown.
56		*1.9	PEBBLES	(55.0 - 57.5) GRANULES and PEBBLES, small to large, some silt, poorly sorted, wet, very loose, brown.
58		*0.0	CL	(57.5 - 60.0) CLAY, some small to large pebbles, non-plastic, no dilatancy, dry, hard, gray.
60				End of boring at 60 feet.
62				

Notes:
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in.: inch
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NA: Not Available
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
ft: feet

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-90**

TOTAL DEPTH: **100 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**	TOP OF CASING:	
LOGGED BY:	**C. Kassel/K. Swiadek**	GROUND ELEVATION:	**727.45**
DATE STARTED:	**12/10/2014**	NORTHING:	**623394.933**
DATE COMPLETED:	**12/15/2014**	EASTING:	**1484777.013**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–6	NM	0.1		SP	(0.0 - 6.0) SAND, coarse, with sub-rounded pebbles, trace silt, well sorted, moist, brown.	Flush Mount (0 to 1 ft) Bentonite (1 to 41.5 ft)
6–8	NM	0.0		FILL	(6.0 - 8.0) FILL, concrete some rebar, poorly sorted, moist, sub-angular, brown.	
8–10	53	0.1		ML	(8.0 - 10.0) SILT, light gray, and granules, some medium sand, small to large pebbles, moist, loose, soft, brown.	
10–12		0.1		GP	(10.0 - 19.0) GRANULES and sand, moist, loose, tan.	
12–18		NM				
18–20		*0.1		SP	(19.0 - 20.0) SAND, coarse, some medium sand, some cobbles, trace silt, wet, soft, tan.	
20–24	48	*NM		CL	(20.0 - 30.5) CLAY, some silt, soft, wet, light gray to gray, some rust, hight plasticity.	
24–26		0.0			Note: At 25 feet some pebbles, dry very hard, tan.	
26–28	84	0.0				
28–30		0.1			Note: At 29 feet medium plasticity, moist.	
30–31		0.1			Note: At 30 feet light brownish gray.	
31–32		0.1		GP	Note: At 30.5 feet clayey silt, tan, pebbles, very hard, poorly sorted, dry, low plasticity.	
32–33		0.1				
33–34		0.5			(30.5 - 54.0) GRANULES, few PEBBLES, medium, trace large pebbles and small cobbles, trace silt, trace sand, medium, sub-	
34–35		0.3				

Notes:

bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife
AMSL: Above Mean Sea Level

Date: 2/27/2015

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-90**

TOTAL DEPTH: **100 feet bls**

PROJECT INFORMATION		DRILLING INFORMATION AMSL	
CLIENT:	**RACER Trust**	DRILLING CO.:	**Stock Drilling**
PROJECT:	**Process Sump Area Investigation**	DRILLER:	**Austin Goldsmith**
CITY, STATE:	**Moraine, Ohio**	DRILLING METHOD:	**Rotosonic**
PROJECT NUMBER:	**OH000294.2014**	TOP OF CASING:	
LOGGED BY:	**C. Kassel/K. Swiadek**	GROUND ELEVATION:	**727.45**
DATE STARTED:	**12/10/2014**	NORTHING:	**623394.933**
DATE COMPLETED:	**12/15/2014**	EASTING:	**1484777.013**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
35–36		0.2			angular to sub-rounded, loose, wet.	
36–38		0.1				
38–40		0.4			Note: At 39 feet some pebbles, trace sand.	
40–41		0.7				
41–42		0.8				Sand Pack (41.5 to 54.0 ft)
42–43		1.1				
43–44	108	0.6				
44–45		*0.2				
45–46		*1.2				
46–47		*1.6				2" Schedule 40 PVC Screen, slot size 0.010 (43.5 to 53.5 ft)
47–48		*0.8				
48–50		*1.5				
50–51		0.6		GP	Note: At 49 feet fining downward to silty coarse sand.	
51–52		0.3				
52–53		0.3				
53–54		0.6				
54–55	117	1.2		ML	(54.0 - 59.0) Clayey SILT, few small pebbles, trace fine sand, sub-angular, poorly sorted, trace granules, light gray, low plasticity, dry.	Bentonite (54 to 58 ft)
55–56		0.7				
56–57		1.0				
57–58		0.4				
58–59		0.3				58 to 100 feet collaspe
59–60		0.3		GP	(59.0 - 68.0) GRANULES with trace small to medium pebbles, trace silt and clay, poorly sorted, rounded, wet, very loose, light brown.	
60–61		*0.3				
61–62		*0.3				
62–64	84	*0.3				
64–66		*0.3				
66–68		0.4				
68–69		0.3		SW	(68.0 - 70.0) SAND, medium to fine, some silt, angular to sub-round, wet, loose, light brown.	
69–70		0.2				

Notes:
bls: below land surface
HA: Hand Auger
NR: Not Recorded
NM: Not Measured
USCS: Unified Soil Classification System
ppm: parts per million
PID: Photo-ionization Detector
HK: Hydroknife
AMSL: Above Mean Sea Level

Date: 2/27/2015

BORING/WELL CONSTRUCTION LOG

WELL NO.: **RMW-90**

TOTAL DEPTH: **100 feet bls**

PROJECT INFORMATION

CLIENT:	**RACER Trust**
PROJECT:	**Process Sump Area Investigation**
CITY, STATE:	**Moraine, Ohio**
PROJECT NUMBER:	**OH000294.2014**
LOGGED BY:	**C. Kassel/K. Swiadek**
DATE STARTED:	**12/10/2014**
DATE COMPLETED:	**12/15/2014**

DRILLING INFORMATION AMSL

DRILLING CO.:	**Stock Drilling**
DRILLER:	**Austin Goldsmith**
DRILLING METHOD:	**Rotosonic**
TOP OF CASING:	
GROUND ELEVATION:	**727.45**
NORTHING:	**623394.933**
EASTING:	**1484777.013**

DEPTH (feet)	Recovery (inches)	PID (ppm)	Soil Symbols	USCS Classification	SOIL DESCRIPTION	WELL CONSTRUCTION DETAILS
70–73	105	0.2, 0.1, 0.1		SP	(70.0 - 73.0) SAND, fine to very fine, rounded, well sorted, wet, medium dense, light brown to tan. Note: At 72 feet more fine sand.	
73–75		0.6, 0.2		CL	(73.0 - 75.0) CLAY, trace silt, medium plasticity, slow dilatancy, moist, stiff, light brown. Note: At 74 feet medium stiff.	
75–79		0.6, 0.3, 0.4, 0.3		SW	(75.0 - 79.0) SAND, medium to fine, trace silt and clay, sub-angular, well sorted, moist, loose, light brown.	
79–85	93	*0.2, *0.2, *0.3, *0.2, *0.2, 0.3		SP	(79.0 - 85.0) SAND and granules to very large pebbles, trace silt, angular to rounded, poorly sorted, very loose, wet, light brown. Note: At 83 to 84 feet decrease in pebbles size.	58 to 100 feet collaspe
85–90		0.2, 0.2, 0.2, 0.4, 0.3		GW	(85.0 - 90.0) PEBBLES, rounded, trace silt, poorly sorted, wet, light brown	
90–100	76	0.2, 0.2, 0.1, 0.1, 0.2, 0.1, 0.3, 0.2, 0.2, 0.2		SP	(90.0 - 100.0) SAND and granules, some small to very large pebbles, trace silt, sub-round, poorly sorted, moist, very loose, gray. Note: At 93 feet more silt, wet, tan. Note: At 96 to 98 feet decrease in very large and large pebbles. Note: At 98 to 100 feet decreasing silt, moist, tan. End of boring at 100 feet.	

Notes:

bls: below land surface
HA: Hand Auger
NR: Not Recorded
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Date: 2/27/2015

APPENDIX B

Standard Operating Procedures (provided on CD)

Appendix B. Standard Operating Procedures

Table of Contents

Appendix B. Standard Operating Procedures

SOP 23	Inspection and Vapor Intrusion Mitigation System Design
SOP 24	Vapor Intrusion Mitigation System Installation
SOP 25	Vapor Intrusion Mitigation System Operation and Maintenance
SOP 26	Groundwater Sampling Using a Direct-Push Sampling System
SOP 27	Subsurface Soil-Gas Point Installation and Sampling
SOP 28	Air Monitoring using an ORION Plus MultiGas Portable Gas Meter
SOP 29	Extraction Step Test
SOP 30	Extraction Constant Rate Test
SOP 31	Injection Step Testing for DGR™ Systems
SOP 32	Recirculation Test for DGR™ Systems

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SOP 1

Vertical Aquifer Profiling

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for the use of vertical aquifer profiling during borehole advancement using sonic or direct push drilling methodologies. This SOP may be modified and/or amended to utilize with other drilling methodologies.

II. Summary of Method

Vertical aquifer profiling can be utilized to obtain groundwater samples at discrete intervals within a boring using various drilling techniques without setting a permanent monitoring well.

III. Health and Safety Considerations

There are no specific health and safety concerns or cautions related to vertical aquifer profiling where there is no soil or groundwater contamination. There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated. The material safety data sheet should be read before using tracer dyes (e.g., fluorescein dye). Some individuals can experience a mild allergic reaction to skin contact with fluorescein. In addition, there are physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to completing drilling activities including vertical aquifer profiling.

IV. Interferences

- The temporary well screen may not be properly sealed off allowing cross contamination between groundwater from intervals other than the target interval.
- Dilution of the groundwater sample from drilling fluids introduced during borehole advancement.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

VI. Equipment and Supplies

Equipment supplied by driller includes:

- Retractable temporary well screen;
- Submersible pump with flow control for extracting drilling fluid and groundwater;
- Poly storage tank; and
- Utility pump for mixing dye.

Equipment supplied by consultant includes:

- Fluorescein tracer;
- Bottles for retaining dyed drilling water samples and prepared visual dye standards;
- Graduated cylinders (50 mL and 1 L);
- Scale for measuring mass of dye to nearest 1 gram;
- Bottles for groundwater sampling;
- Digital camera;
- Potable water source;
- Chain of custody;
- Field forms; and
- Flashlight or other portable lighting device.

VII. Vertical Aquifer Profiling using Sonic Drilling Methods

Dye Batch Preparations

1. Prior to drilling, measure the proper mass of powdered dye for mixing with drilling water – 38 grams of fluorescein will be added to every 500 gallons of water to yield on average tracer concentration of approximately 20 mg/L.

2. If the drilling water "batch" is larger or smaller than 500 gallons, the same ratio of dye to drilling water will be used.

3. Measure the mass of the dye using a scale with an accuracy of +/- 1 gram.

4. Add the dye to the drilling water batch tank while also adding potable water to provide agitation to assist mixing the dye.

5. A utility pump should also be used to mix the tracer with the drilling water be recirculating water in the tank for at least 5 minutes. Alternatively, if equipped, the water can be recirculated using the internal piping of the drill rig.

6. Place 40 mL of the dyed drilling water into the 50 mL graduated cylinder for use in preparing the visual standard discussed below.

7. Collect 4 additional 40 mL unpreserved VOA vials from each batch of drilling water – label all four of these vials "DW-1" for the first batch of drilling water, "DW-2" for the second batch, etc. These samples will be archived for potential use in preparing other standards with other dilutions (optional) of for submittal for laboratory analysis, if necessary.

8. A visual standard will be prepared for each batch of dyed drilling water, as follows:

   - Pour 40 mL of dyed drilling water from the 50 mL graduated cylinder into the 1 L graduated cylinder.

   - Add 760 mL oh un-dyed potable water to the 1 L graduated cylinder to produce 800 mL of "visual standard".

- Fill one 40-mL unpreserved VOA vial with visual standard solution and label "VS1" for the visual standard from the first batch of drilling water, "VS2" for the visual standard from the second batch of drilling, etc.

- These visual standards represent a 95% dilution of the drilling water, and will provide a visual standard to verify that sufficient purging has been performed to remove at least 95% of the drilling water from a given interval, indicating that the purge water consists of at least 95% formation water.

- Discard the remaining fluid within the graduated cylinder using an appropriate container.

- Photograph the "DW" samples and the "VS" sample from each batch of drilling water with adequate, consistent light, against a white background.

- Keep all of the dyed drilling water ("DW") samples and visual standard ("VS") samples in a cooler to keep them dark, as the dye will degrade with exposure to light.

- If the tracer batch tank is translucent, then black, 1 millimeter plastic will be used to cover the tank during the day to minimize photodegradation of the tracer batch water.

- The drilling water source should be sampled for chlorine and pH at the start of the project. Chlorine will consume fluorescein; if present in detectable quantities, there should be a "wait period" of at least four hours between dye addition and sampling (and use) of the drilling fluid. pH values below approximately 5 standard units results in reduced fluorescence of the fluorescein.

Drilling Procedures

1. The borehole will be advanced following a sonic drilling to the target sampling depth.

2. Ideally, the borehole should be advanced dry without any drilling fluids but if this cannot be done then the dyed drilling water will be used.

3. If using drilling water, a positive head should be maintained during drilling, which should prevent dilution of the drilling water by formation water. However, any water upwelling from the casing during drilling will be contained in a tub positioned over the borehole.

4. A retractable temporary well screen will be placed inside the casing and lowered to the target depth.

Groundwater Sampling Procedures

1. The targeted sample interval will be purged using a pump. During purging, purge water will be periodically collected in a 40-mL unpreserved VOA vial and compared to the visual standard ("VS" sample) prepared from the drilling water used to drill that depth interval.

2. If the purge water contains significant suspended particulates/turbidity, it may be necessary to allow particulates to settle before comparing the purge water sample to the visual standard.

3. Purging will continue until one of the following two conditions is met:

    - The purge water clarity in terms of remaining dye content matches or exceeds the clarity of the visual standard, indicating that the purge water consists of at least 95% formation water.

        - In this case, the purge water sample and the associated visual standard will be photographed against a white background to document that the purging goal has been reached.

    - A different practical purging limit has been reached, based on purge volume or time.

        - In this case, the purge water sample and the associated visual standard will be photographed against a white background to document the degree of purge water visual clarity that was attained.

        - Also, a sample of the purge water (optional) will be obtained in a 40mL unpreserved VOA vial; this sample, and one of the vials of dyed drilling water, will be submitted for quantitative analysis of fluorescein. The analytical results for fluorescein will be used to calculate a COC correction factor, if deemed necessary.

- After purging has been completed, the pumping flow rate will be lowered to or below 1,000 mL/min and then groundwater samples will be collected from the discharge end of the pump tubing for COC analysis in accordance with the approved work plan.

VIII. Aquifer Profiling using Direct Push Drilling Methods

Drilling Procedures

1. The borehole will be advanced using direct push drilling by driving the tool string to the desired sampling depth.

2. Once the targeted sampling depth has been reached, the SP-22 screen with 1.25 inch center rods will be lowered inside the borehole casing.

3. Once the screen is in place, the outer casing will be retracted to expose the screen.

4. A submersible pump and disposable tubing will be lowered into the well and a grab groundwater sample will be collected.

IX. Data and Record Management

All relevant information regarding vertical aquifer profiling including, sample depths, purging volumes, drilling fluid usage and volumes will be recorded in field book (see SOP 18). The groundwater analytical data will be saved electronically once field work is completed.

X. Quality Control and Quality Assurance

Duplicate groundwater samples will be collected a rate specified in the QAPP to ensure accuracy when sampling.

XI. References

None.

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SOP 2

Chain-of-Custody, Sample Labeling and Sample Shipping Procedures

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody (COC), handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, miss-identification, and breakage, and to ensure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory. A COC must be completed by the sampling team for all samples immediately upon collection. The COC will be delivered to the analytical laboratory. A sample COC is included in Appendix B. When shipping laboratory samples it is necessary that the correct procedures are followed in order for the subsequent analytical data to be valid and useable.

II. Summary of Method

When samples are collected, the appropriate sample label should be completed and placed on the sample as soon as it is collected. An example sample label is included in Appendix B. In addition, the COC shall be completed upon the collection of the sample. After the sample is collected and correctly label, the sample should be immediately placed in a cooler with wet ice. When shipping samples, the COC should be included and should match the sample labels placed on the containers. The samples should be shipped on ice for morning delivery to the destination laboratory.

NOTE: In some cases, the COC might be completed at the end of a sampling event in which each sample collected does not warrant laboratory analysis. In this scenario a running list of samples collected should be kept in the field notes or on another field form to ensure that every sample is tracked.

III. Health and Safety Considerations and Cautions

Care should be taken when handling sample containers with preservatives which could be harmful. Preserved containers could off-gas when opened and/or be acidic/caustic. Coolers containing sample bottles and ice become very heavy; the transportation of these coolers should be done in a manner to reduce the possibility of injury. In addition, the site-specific health and safety plan should be consulted before completing any field work.

IV. Interferences

- It is important that all sample containers be accurately labeled. The COC should match the label placed on the container. If this is not done correctly, the receiving laboratory may not be able to distinguish between samples, causing confusion and possible loss of or misidentification of samples.

- Samples should be shipped on wet ice in coolers for morning delivery to the destination laboratory. If the receiving laboratory does not receive the samples in a timely manner the samples could violate temperature and/or holding time restrictions.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Sample containers;
- Indelible ink pens (black or blue);
- Daily field log (example attached in Appendix B) or logbook;
- Coolers;
- Re-sealable bags (e.g. Zip-lock™ bags);
- Clear packing tape, strapping tape;
- Department of Transportation shipping forms, as applicable;
- Chain-of-Custody (example attached in Appendix B);
- Custody seals (example attached in Appendix B);
- Wet ice;

- Cushioning and absorbent material (i.e., bubble wrap or bags);
- Temperature blank; and
- Sample labels (example attached in Appendix B).

VII. COC, Sample Labeling and Sample Shipping Procedures

1. The sample should be labeled in accordance with the Quality Assurance Project Plan for the project.
2. When labeling the sample, ensure that the correct time and date, preservative, and medium are correct.
3. Complete all information fields (MUST PRINT LEGIBLY) on the COC including project name, project location, laboratory, project manager, and sampler.
4. When a sample is collected, complete the COC with the sample identification, matrix, date and time, sample container, analytical parameters or method number, and preservative.
5. Ensure that the COC and sample label correspond, especially in terms of sample identification, date, and time.
6. Protect the sample with appropriate shipping materials (e.g. bubble wrap) and place the sample in an ice filled cooler.
7. Prior to shipping the samples, complete another check to ensure that the COC has a record of every sample container to be shipped in the cooler. Each cooler must contain a COC. A cooler may have more than one COC.
8. Prior to shipping, drain free water from the cooler, place sealed, ice-filled plastic bags around the samples, and ensure that the sample containers are protected from breakage.
9. Sign/relinquish the COC, keeping a carbon copy for the file, and seal the COC in a baggie.

10. Seal the cooler with tape and place a cooler COC seal over the opening, sign and date.

11. Ship the cooler to the destination laboratory via overnight courier.

VIII. Data and Record Management

As described the data should be recorded as described in the appropriate forms. Chain-of-custody records will be transmitted to the ARCADIS Project Manager or designee at the end of each day unless otherwise directed by the ARCADIS Project Manager. The sampling team leader retains copies of the chain-of-custody forms for filing in the project file. When appropriate, this recorded data will be input and/or tabulated electronically. Record retention shall be in accordance with project requirements

IX. Quality Control and Quality Assurance

After fieldwork is completed, the COC and field notes will be used for the validation of the field sampling event.

X. References

None.

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SOP 3

Calibration and Use of Photo Ionization Detector for Field Screening of VOCs

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure is for health and safety monitoring and screening surface or subsurface soil samples collected in the field for volatile organic compounds (VOCs) using a photo-ionization detector (PID). The purpose of this procedure is to provide uniformity in the field screening of soil samples. In addition, a PID may be utilized for health-and-safety monitoring. Non-volatile chemicals will not be detected by a PID, and that different PID lamp sizes enable detection sensitivity of different VOCs.

II. Summary of Method

In order to collect uniform field screening data, it is necessary to follow the guidelines set forth in this SOP. Soil screening for VOCs in the field is a good estimate of relative concentrations in a given sample. Screening can also be useful in determining the presence or absence of VOCs in soil samples. A PID can also be utilized for health-and-safety monitoring. To ensure consistency during sampling, the PID is to be calibrated daily according to the manufacturer's instructions.

III. Health and Safety Considerations and Cautions

Collecting and screening samples of contaminated soil could pose health and safety concerns related to direct contact, ingestion, and/or inhalation. Utilizing pressurized gas during calibration should be done with care. Installing or removing fittings on a pressurized gas canister could lead to the release of pneumatic pressure. The site specific health and safety plan must be consulted before conducting these activities.

IV. Interferences

- The area in which the PID readings are collected should be free of any background VOCs, or, if this is not able to be accomplished, an ambient air background VOC reading should be noted and recorded or a zero-air pressurized gas canister used.
- The intake port of the PID should be clear of any debris and/or water.
- As with any piece of equipment, it is necessary that it be properly calibrated and checked to ensure that readings are not artificially high or low. The

equipment should be calibrated in an area in which the background environment is not influenced by VOCs.

- High humidity could result in erratic readings.
- The appropriate regulator should be utilized when calibrating the PID, use of an incorrect regulator will lead to erroneous readings.
- The appropriate correction factor should be used when measuring total VOC concentrations. Each specific VOC will have an independent correction factor based on the standard in which the PID was calibrated. You should refer to the manufacturer's manual for a list of correction factors.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course, associated 8-hour refresher courses, and the any site-specific required training prior to engaging in any field activities.

VI. Equipment and Supplies

- Photo-ionization detector (PID) including manual;
- Calibration Gas, tubing and regulator;
- Particulate filter;
- Sealable plastic bags (e.g., Ziploc bags); and
- Soil boring log and/or soil sampling log.

VII. Calibration of PID

- Record the time of calibration (cal), PID serial number, and calibration gas lot number and expiration date in the daily log.
- Turn on instrument and record the pre-calibration reading.

- Follow the manufacturer's instructions to zero the meter by applying ambient or zero air.

- Follow the manufacturer's instructions to calibrate the meter by applying SPAN calibration gas of known concentration (e.g. isobutylene at 100 ppm concentration).

- Following calibration, complete a bump test to ensure the instrument is reading correctly. If the reading shown by the instrument is greater than ± 10% of the cal gas concentration, relocate to an area not influenced by VOCs and recalibrate.

Calibration Check:

  - o Exit the work area and turn meter to "on" position. Check that the meter is reading a value of zero.
  - o Perform steps 1 and 2 from "Instrument Daily Calibration" above.
  - o Attach the 100 ppm SPAN gas and verify that the reading is within 10 ppm of 100.

- If the value shown by the instrument is greater than 10% of the calibration gas concentration, take meter away from work zone and recalibrate as outlined above.

VIII. Field Screening of Sample

- Sample Preparation

  - o Before classification of the soil, collect and preserve samples for laboratory analysis (if any).
  - o Collect the sample and place into a sealable plastic bag. Attempt to decant as much free water from the sample as possible if the sample is saturated.
  - o The sample should be allowed to remain in the sealed bag for approximately 10 minutes. To enhance volatilization, the samples should be broken apart and placed in a heated area.

- Sample Screening

  - Ensure that the PID is calibrated and is reading zero in an uncontaminated ambient air environment. If a zero reading is not able to be obtained, an ambient air background VOC reading should be recorded.

  - Slightly open the sealed bag containing the soil sample and insert the PID probe into the bag making sure that the probe does not contact any soil or fluid in the bag.

  - Record the peak reading on the boring log and/or soil sampling log.

  - Remove the PID probe from the bag and confirm that the PID reading returns to zero or to the site background concentration in ambient air. If the PID does not return to zero or to the site background concentration, check the PID probe and recalibrate the PID.

  - Dispose of the soil in accordance with applicable environmental regulations (SOP 9).

IX. Data and Record Management

Screening results, calibration data, and other relevant information must be documented in the daily field log, logbook and/or calibration log. After completion of field tasks, the logs will be scanned and saved electronically.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original boring logs and/or soil sampling logs. The logs will be reviewed to ensure that the field soil screening data was correctly transferred to the electronic logs.

XI. References

None.

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SOP 4

Soil Sample Collection and Classification

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) applies to collecting surface and subsurface soil samples in the field and classifying the soil samples. This SOP incorporates elements from various standard systems such as American Society for Testing and Materials (ASTM) D2488-06, Unified Soil Classification System (USCS), and the Wentworth Classification System. This SOP has been developed to emphasize field observation and documentation of details required to:

- Make hydrostratigraphic interpretations guided by depositional environment/geologic settings.
- Provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.
- Collection of soil samples for field screening and possible laboratory analysis.

The purpose of this procedure is to provide uniformity in soil description and classification.

II. Summary of Method

In order to objectively record lithologic information it is necessary to follow the guidelines set forth in this SOP. The use of standard classifications systems will allow for a uniform description of soils between field personnel. Use of this SOP will ensure that all required lithologic information is recorded.

III. Health and Safety Considerations and Cautions

Collecting and classifying samples of contaminated soil could pose health and safety concerns associated with direct contact, ingestion, and/or inhalation. The site specific health and safety plan must be consulted before conducting these activities.

IV. Interferences

This SOP and use of the Udden-Wentworth Grain Size Scale and USCS will minimize the subjectivity inherent in describing soil characteristics.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Soil descriptions shall be documented by a qualified on-site geologist. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist.

VI. Equipment and Supplies

- Stainless steel butter knife or other cutting utensil;
- Plastic sheeting;
- USCS classification Geotechnical Gauge or similar;
- Soil Description Field Guide (attached);
- Soil boring log and/or soil sampling log (attached in Appendix B);
- Distilled water;
- Field card showing Wentworth scale;
- Munsell® soil color chart;
- Tape measure divided into tenths of a foot;
- Hand lens;
- Digital camera;
- Sealable plastic bags;
- Sample jars and lids;
- Nitrile Gloves;

- Clear Tape;
- Personal protective equipment (PPE) as required by the HASP; and
- Decontamination equipment.

VII. Classification of Sample

Sample Preparation

1. Before classification of the soil, collect and preserve samples for field PID screening and laboratory analysis (if any).

2. Complete labels for samples for laboratory analysis and complete chain-of-custody. Store sample containers in an ice-filled cooler pending shipment to the laboratory (see SOP 2).

3. Place sample on disposable plastic sheeting. If the sample has been collected from a boring, ensure that the top of the sample can be differentiated from the bottom.

4. If the sample is a cohesive soil such as clay, cut the sample down the middle using a previously decontaminated cutting utensil in order to expose a clean surface.

Sample Classification

1. Soil classification based on the Udden-Wentworth grain size scale.

   Determination of components is based on using the Udden-Wentworth particle size classification and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Udden-Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the field gauge card that shows Udden-Wentworth scale or by measuring with a ruler. An optional settling test or wash method (Appendix X4 of ASTM D2488) may be used for determining presence and estimating percentage of clay and silt.

2. Describe the color (dark gray, light gray, yellowish orange, etc.) of the sample and compare it to the Munsell® soil color chart descriptions. Record the color in the soil boring log and/or soil sampling log.

3. Characterize the degree of saturation of the sample. Use the terms "dry", "moist", or "wet".

4. Determine the minor and major components of the soil (clay, silt, sand, gravel, angularity, plasticity, dilatancy, sorting, etc.). Record the information in the soil boring log and/or soil sampling log.

5. To measure and record the depth below ground surface (bgs) of top and bottom of each stratum, the following information should be recorded.

   - Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.

   - Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).

   - Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.

   - Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval.

6. Describe the overall texture and appearance of the sample. Is the sample homogeneous or is it divided into discreet lenses or layers of different grain sizes (as is often the case)? Are there any abrupt changes in grain size, color, degree of saturation, or consistency?

7. If the major component of the sample is silt or clay, describe the consistency based on the USCS description (hard, medium, stiff, etc.) and indicate the method used to designate consistency (e.g., n-value, penetrometer, etc.).

8. If the major component is sand or gravel, note the grain size and assign the appropriate Udden-Wentworth descriptor (medium sand, coarse gravel, cobble, etc.) and the relative percentage of materials of that size. Record the sizes and percentages in the soil boring log and/or soil sampling log.

9. Select the appropriate 2-letter soil descriptor from the USCS classification chart. Record the letter symbol in the soil boring log and/or soil sampling log.

10. Record additional relevant information such as evidence of contamination, presence of organic material (roots, etc.) or anthropogenic material (e.g., brick, plastic), and evidence of soil structures (e.g., mottling, micro-fractures, etc.).

11. Document formation types and unusual features with photographs.

12. Complete field screening (if required) after completing boring log entry. Record field screening data on boring log (see SOP 3).

VIII. Data and Record Management

Submit copies of all field logs to the project manager at the end of each work day. Keep original versions of all field logs in the field until the end of the project. Field-generated logs will be converted into electronic logs.

IX. Waste Management

Project-specific requirements should be identified and followed.

The following procedures or similar waste management procedures are generally required. Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/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.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. For more information on investigative derived waste handling and sampling see SOPs 9 and 19.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original boring logs and/or soil sampling logs. The electronic logs will be reviewed for completeness and accuracy.

XI. References

Geotechnical Gauge, WF McCollough.

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder".

ARCADIS Soil Description Field Guide, July 10, 2008.

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts.

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

THIS BAR REPRESENTS 1 INCH ON THE ORIGINAL DRAWING. USE TO VERIFY FIGURE REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JULY 10, 2008; REV. 0.0)

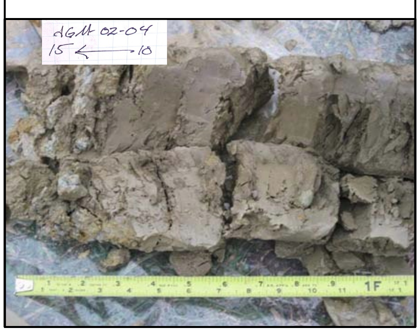
ARCADIS

FINE-GRAINED SOILS

Description	Criteria
	Descriptor - Plasticity
Nonplastic	A 1/8-inch (3mm) thread cannot be rolled at any moisture content.
Low	Thread can barely be rolled, and lump cannot be formed when drier than plastic limit.
Medium	Takes considerable time and rolling to reach plastic limit. Thread cannot be rolled after reaching plastic limit. Lump crumbles when drier than plastic limit.
High	Thread is easy to roll and quickly reaches plastic limit. Thread can be rerolled several times after reaching plastic limit. Lump can be formed without crumbling when drier than plastic limit.
	Descriptor - Dilatancy
No Dilatancy	No visible change when shaken or squeezed.
Slow	Water appears slowly on the surface of soil during shaking and does not disappear or disappears slowly when squeezed.
Rapid	Water appears quickly on surface of soil during shaking and disappears quickly when squeezed.
Minor Components with Descriptors	
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Consistency
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated 1 inch by thumb.
Medium stiff	N-value 5-8 or indented about 1/2 inch by thumb with great effort.
Stiff	N-value 9-15 or indented about 1/4 inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty.
Color using Munsell	
Geologic Origin (if known)	
Other	

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10 feet to 15 feet Clay, some silt, medium to high plasticity; trace small to very large pebbles, subround to subangular up to 2 inches diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10YR 4/3).



DESCRIPTION ORDER

Depth Interval
Principal Components with Descriptors
Minor Components with Descriptors
Sorting
Field Moisture Condition
Density/Consistency
Color using Munsell
Geologic Origin (if known)
Other descriptions as NOTES:
- Odor
- Stratigraphy
- Structure
- Sphericity
- Cementation
- Reaction to acid

MINOR COMPONENTS % MODIFIERS

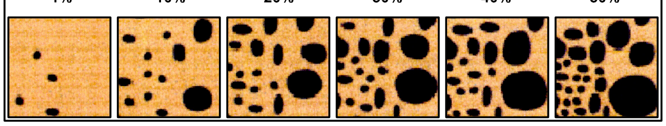
Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

UDDEN-WENTWORTH SCALE

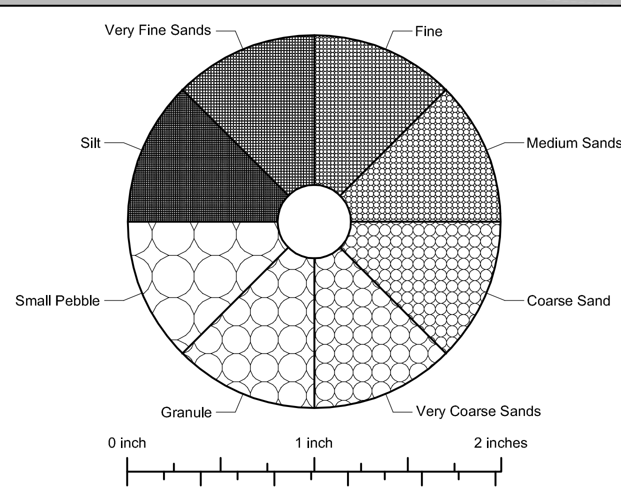
Fraction	Sieve Size	Grain Size	Approximate Scale
Boulder		256 - 4096 mm	Larger than volleyball
Large Cobble		128 - 256 mm	Softball to volleyball
Small Cobble		64 - 128 mm	Pool ball to softball
Very Large Pebble		32 - 64 mm	Pinball to pool ball
Large Pebble		16 - 32 mm	Dime size to pinball
Medium Pebble		8 - 16 mm	Pencil eraser to dime size
Small Pebble	No. 5+	4 - 8 mm	Pea size to pencil eraser
Granule	No. 10 - 5	2 - 4 mm	Rock salt to pea size
Very Coarse Sand	No. 18 - 10	1 - 2 mm	See field gauge card
Coarse Sand	No. 35 -18	0.5 - 1 mm	See field gauge card
Medium Sand	No. 60 - 35	0.25 - 0.5 mm	See field gauge card
Fine Sand	No. 120 - 60	0.125 - 0.25 mm	See field gauge card
Very Fine Sand	No. 230 - 120	0.0625 - 0.125 mm	See field gauge card
Silt and Clay. See SOP for description of fines	Not Applicable	<0.0625 mm	Analyze by pipette or hydrometer

PARTICLE PERCENT COMPOSITION ESTIMATION

1%	10%	20%	30%	40%	50%



GRAPH FOR DETERMINING SIZE OF PARTICLES



FOR COARSE-GRAINED SOILS

Description	Criteria
	Descriptor - Angularity
Angular	Particles have sharp edges and relatively planar sides withunpolished surfaces.
Subangular	Particles are similar to angular but have rounded edges.
Subround	Particles have nearly planar sides but have well-roundedcorners and edges.
Round	Particles have smoothly curved sides and no edges.
Minor Components with Descriptors	
	Sorting Cu= d60/d10
Well Sorted	Near uniform grain-size distribution Cu= 1 to 3.
Poorly Sorted	Wide range of grain size Cu= 4 to 6.
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Density
Very loose	N-value 1 - 4
Loose	N-value 5 - 10
Medium Dense	N-value 11 - 30
Dense	N-value 31 - 50
Very dense	N-value >50
Color using Munsell	
Geologic Origin (if known)	
Other	
	Cementation
Weak Cementation	Crumbles or breaks with handling or little finger pressure.
Moderate Cementation	Crumbles or breaks with considerable finger pressure.
Strong Cementation	Will not crumble with finger pressure.
	Reaction with Dilute HCl Solution (10%)
No Reaction	No visible reaction.
Weak Reaction	Some reaction, with bubbles forming slowly.
Strong Reaction	Violent reaction, with bubbles forming immediately.

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10 feet to 15 feet Sand, medium to pebbles, coarse, subround to subangular; trace silt; poorly sorted; wet; grayish brown (10YR5/2).

THIS BAR REPRESENTS 1 INCH ON THE ORIGINAL DRAWING. USE TO VERIFY FIGURE REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JULY 10, 2008; REV. 0.0)

ARCADIS

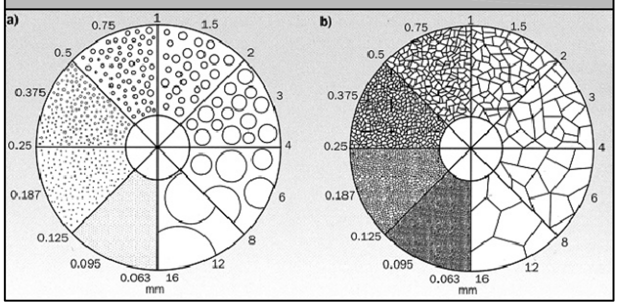
VARIATIONS IN SOIL STRATIGRAPHY

Term	Thickness of Configuration
Parting	0 - to 1/16-inch thickness.
Seam	1/16 - to 1/2-inch thickness.
Layer	1/2 - to 12-inch thickness.
Stratum	> 12-inch thickness.
Pocket	Small erratic deposit, usually less than 1 foot in size.
Varved Clay	Alternating seams or layers of sand, silt, and clay (laminated).
Occasional	≤ 1 foot thick.
Frequent	> 1 foot thick.

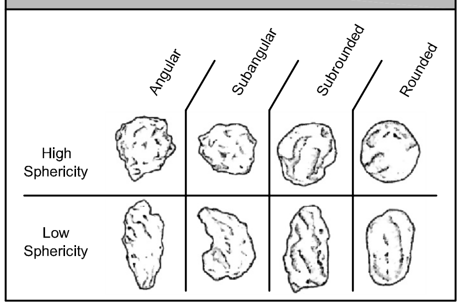
SOIL STRUCTURE DESCRIPTIONS

Term	Description
Homogeneous	Same color and appearance throughout.
Laminated	Alternating layers < 1/4 inch thick.
Stratified	Alternating layers ≥ 1/4 inch thick.
Lensed	Inclusions of small pockets of different materials, such as lenses of sand scattered through a mass of clay; note thickness.
Blocky	Cohesive soil can be broken down into small angular lumps, which resist further breakdown.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated.

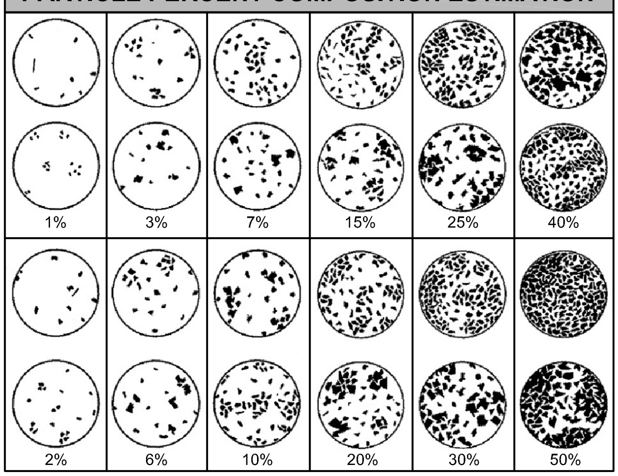
GRAPH FOR DETERMINING SIZE OF PARTICLES



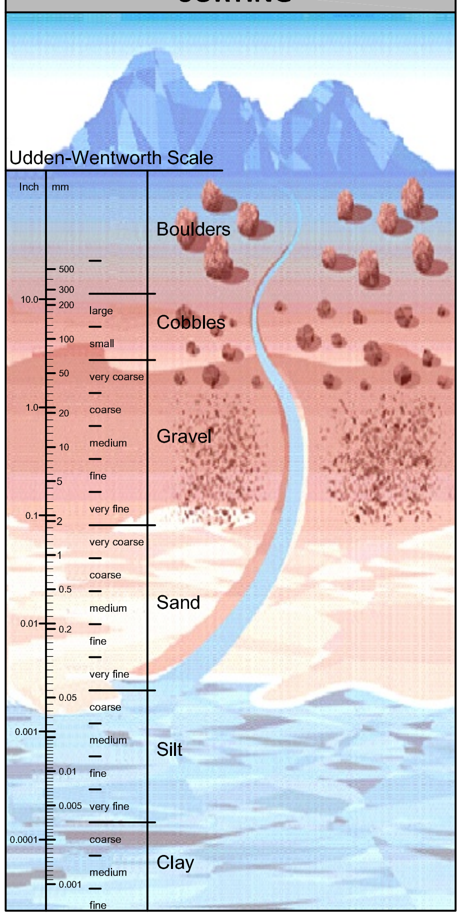
ANGULARITY CHART



PARTICLE PERCENT COMPOSITION ESTIMATION



SORTING



SETTLING TABLE (SILT/CLAY)

Diameter of Particle (mm)	<0.625	<0.031	<0.016	<0.008	<0.004	<0.002	<0.0005
Depth of Withdrawal (cm)	10	10	10	10	5	5	3
Time of Withdrawal	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec
Temperature (Celsius)							
20	00:00:29	00:01:55	00:07:40	00:30:40	00:61:19	04:05:00	37:21:00
21	00:00:28	00:01:52	00:07:29	00:29:58	00:59:50	04:00:00	
22	00:00:27	00:01:50	00:07:18	00:29:13	00:58:22	03:54:00	
23	00:00:27	00:01:47	00:07:08	00:28:34	00:57:05	03:48:00	
24	00:00:26	00:01:45	00:06:58	00:27:52	00:55:41	03:43:00	33:56:00
25	00:00:25	00:01:42	00:06:48	00:27:14	00:54:25	03:38:00	
26	00:00:25	00:01:40	00:06:39	00:26:38	00:53:12	03:33:00	
27	00:00:24	00:01:38	00:06:31	00:26:02	00:52:02	03:28:00	
28	00:00:24	00:01:35	00:06:22	00:25:28	00:50:52	03:24:00	31:00:00
29	00:00:23	00:01:33	00:06:13	00:24:53	00:49:42	03:10:00	
30	00:00:23	00:01:31	00:06:06	00:24:22	00:48:42	03:05:00	

Imagine the result

SOP 5

Hydrophobic Dye Smear Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for the use of applying hydrophobic dye to soil samples. The purpose is to qualitatively determine the presence of non-aqueous phase liquids (NAPL) within soil by a positive or negative result from the dye.

II. Summary of Method

In order to complete the hydrophobic dye smear test in a uniform manner, it is necessary to follow the guidelines set forth in this SOP. The application of hydrophobic dye to a soil sample can allow for a quick analysis of the presence or absence of NAPL within a soil sample interval.

III. Health and Safety Considerations and Cautions

There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated and impacted with NAPL. The material safety data sheet should be read before using a hydrophobic dye. Caution should be used when combining soil with a hydrophobic dye to ensure the correct ratio is utilized (see section VII). In addition, there are always physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to performing vertical aquifer profiling activities.

IV. Interferences

None.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

VI. Equipment and Supplies

- Hydrophobic dye (Oil Red O© dye or similar);
- Measuring spoon (teaspoon);
- Disposable plastic dishes or cups; and

- Distilled Water.

VII. Hydrophobic Dye Smear Test

- Approximately 10 cubic centimeters (cc) of soil and 1 cc of Oil Red O© dye powder produced by Rowley Biochemical, will be placed into a small disposable dish.

- Depending on the soil moisture content, distilled water will be added to the mix of dye and soil.

- The soil and dye will be mixed and smeared together into a paste consistency in the dish by hand with a nitrile-glove.

- All soil samples containing NAPL will produce a distinct red color within the soil and/or on the glove. Samples without NAPL will not exhibit any coloration change within the soil and on the glove.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

None.

X. References

None.

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 6

Decontamination of Heavy Equipment

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) applies to heavy equipment, such as drill rigs, well casings/tooling, and auger flights. These could contain potential sources of interference to environmental samples. The sampling equipment may have come in contact with the materials adjacent to the matrix being sampled or media may be attached to the actual sampling equipment. For these reasons, it is important that the sampling equipment be cleaned prior to use.

Two methods are used for cleaning heavy equipment: pressure washed and/or steam-cleaning and manual scrubbing. Pressure washed and/or steam-cleaning can remove visible debris. Since these provide a high pressure medium, they are very effective for solids removal. They are also easy to handle and generate low volumes of wash solutions.

Heavy equipment will be thoroughly pressure washed and/or steam-cleaned or manually scrubbed upon arrival on site and when moved between sampling locations. Drill rig items (such as auger flights, drill rods, and drill bits) will be cleaned before changing sample locations

II. Summary of Method

Decontamination procedures are used to remove the presence of contaminants from heavy equipment and associated sampling equipment prior to use and between sampling locations. Decontamination consists of cleaning the equipment with the use of water and reagent grade soap, wiping it dry, or steam cleaning.

III. Health and Safety Considerations and Cautions

Residual media removed during decontamination may pose a health and safety hazard. High pressure and/or steam washing poses hazards associated with flying debris pressurized hoses/vessels and scalding/burns. Generate a Job Loss Analysis for each piece of equipment and follow the site-specific health and safety plan before completing this activity.

IV. Interferences

If equipment is not appropriately decontaminated, the possibility for cross-contamination exists. If this SOP is followed strictly, the possibility of cross-contamination between sampling locations can be diminished.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Equipment to be decontaminated;
- Potable water;
- Pressure washer and/or steam Cleaner;
- Reagent grade soap;
- Paper towels;
- Brushes;
- Field logbook or daily log; and
- 55-gallon drums or poly tank.

VII. Decontamination Procedures

- Use steam cleaner to provide a high pressure, high temperature wash and rise to equipment.
- Visually inspect equipment for signs of visible contamination.
- Repeat steps 1 and 2 as necessary.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

None.

X. References

None.

Imagine the result

SOP 7

Decontamination

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for decontaminating non-dedicated field equipment. Non-dedicated sampling equipment must be decontaminated to eliminate the possibility of sample cross-contamination at a given sample location or between multiple sampling locations. Typically, this equipment is constructed of stainless steel or other impermeable material. Use of plastic equipment is discouraged and should only be used when contaminant levels are anticipated to be relatively low.

II. Summary of Method

Decontamination procedures are used to remove the presence of contaminants from sampling and/or monitoring equipment prior to use and between sampling locations. Decontamination consists of cleaning the equipment with the use of water and laboratory quality detergent, rinsing, and wiping or air drying.

III. Health and Safety Considerations and Cautions

Residual media removed during decontamination may pose a health and safety hazard. The site-specific health and safety plan should be consulted before conducting this activity.

IV. Interferences

If equipment is not appropriately decontaminated, the possibility for cross-contamination exists. If this SOP is followed strictly, the possibility of cross-contamination between sampling locations can be diminished.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

Equipment to be decontaminated:

- Distilled water (potable water is acceptable in equipment in which samples are not collected);
- 5-gallon buckets or similar clean container;
- Laboratory quality detergent (i.e. Alconox);
- Paper towels;
- Brushes;
- Field logbook or daily log; and
- Sealable Plastic Bags.

VII. Decontamination Procedures

1. Fill one clean 5-gallon bucket (or similar) with distilled (or potable where appropriate) water and detergent, this will be the initial decontamination step. Fill another clean 5-gallon bucket with distilled (or potable where appropriate) water; this will be the second step. If equipment is heavily soiled add an additional bucket of a detergent/water mix prior to the first bucket.

2. Remove any solid debris and/or soil from the equipment to be decontaminated and place the equipment into the 5-gallon bucket with the detergent/water mixture.

3. Agitate the equipment in the detergent/water mixture and scrub with a brush making sure the entire surface of the equipment is cleaned.

4. Remove the equipment from the detergent/water mixture and place into the 5-gallon bucket with distilled (or potable where appropriate) water.

5. Agitate the equipment in the water and scrub with a brush making sure the entire surface of the equipment is cleaned.

6. Inspect the equipment to ensure that there is no residue which would indicate possible contamination. If residue is observed, repeat steps 3 through 6.

VIII. Data and Record Management

Information regarding decontaminated of equipment should be recorded in the daily log and/or field log book.

IX. Quality Control and Quality Assurance

Rinsate blanks, also known as equipment blanks (SOP 15), will be collected at a rate specified in the QAPP. These samples will be submitted for laboratory analysis and be used for data validation purposes.

X. References

None.

ARCADIS

Infrastructure, environment, buildings

Imagine the result

SOP 8

Borehole and Well Abandonment

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for abandoning a borehole or temporary/permanent monitoring well or piezometer. Correct procedures are to be followed to reduce the possibility of vertical migration of surface water or groundwater into an open borehole or between water bearing zones separated by an aquitard, eliminate the potential for the borehole to expand by cave-in, and eliminate the potential for accidental injury. The procedures in this SOP concur with the requirements of the Ohio Department of Natural Resources and the Ohio Administrative Code 3745-9-07 and 3745-9-10.

II. Summary of Method

Removing of well materials from a borehole or pulling of drilling materials such as augers will leave an open borehole which requires proper abandonment. Abandonment of a borehole requires backfilling with a permanent, non-permeable fill material such as bentonite or cement/bentonite grout to seal off the borehole from the migration of water.

III. Health and Safety Considerations and Cautions

There is direct-contact, ingestion, and inhalation concerns at sites where soil or groundwater is contaminated. Further, there are physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to performing borehole or well abandonment activities.

IV. Interferences

If the borehole or well is incorrectly abandoned, preferential groundwater communication across and aquitard may occur. Proper abandonment procedures will eliminate the potential for vertical cross contamination.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, prior to engaging in any field activities along with any site-specific training which is required for the site.

VI. Equipment and Supplies

- Field logbook and/or daily log (see Appendix B);
- Weighted tape;
- Electronic water level meter; and
- Non-permeable fill material (i.e. cement, bentonite).

VII. Abandonment Procedures

Abandonment of a soil boring:

1. Before abandoning the borehole, collect a depth-to-water (SOP 16) and total depth reading inside the boring if possible. Record these measurements in the log book and/or daily log (SOP 18).

2. Have the drilling subcontractor mix cement / bentonite slurry or pour bentonite chips inside the boring until all the annular void is filled with slurry or chips. Drilling materials, such as rods and augers, should be retracted from the borehole slowly to decrease the possibility of bridging if using bentonite chips.

3. Where necessary, the cement grout shall be pumped to the bottom of the borehole by use of a “tremie” pipe. The tremie pipe should be inserted to the bottom of the boring, and the grout pumped through the pipe filling the borehole from the bottom to the top. The tremie pipe can be removed as the borehole is being filled with grout.

4. After the borehole is completely abandoned, record all relevant information in your field log book and/or daily log including the volume of material used to abandon the borehole (SOP 18).

5. Decontaminate all drilling equipment per SOP 6.

6. Check the abandoned borehole the next day to see if any settlement has occurred. If settlement has occurred, fill in the remaining space with grout, bentonite, concrete, or soil depending on the final use of the area and the amount of settling below grade.

Abandonment of a well (temporary or permanent) screened in one water bearing zone:

1. Before abandonment of the well, collect depth-to-water and total depth measurements in the monitoring well.

2. Have the drilling subcontractor remove any protective well materials such as a procasing or flush-mount, if applicable. These materials can be disposed of as municipal waste.

3. Have the drilling subcontractor slowly remove the well by applying an even upward force onto the riser pipe.

4. If the well casing breaks upon the attempted removal, use drilling rods or similar to advance the well to the bottom of the original borehole. In this scenario, tremie in a cement/bentonite slurry from the bottom of the well to land surface. If the well is able to be completely removed, fill the open annular space with bentonite or a cement/bentonite slurry. In the rare occurrence in which the well is unable to be pulled due to access or safety concerns, fill the inside of the well screen to one-foot above the screen with sand, fill the rest of the of the well with bentonite or a cement/bentonite grout.

5. Ensure that the land surface is completed to grade level to decrease a trip hazard.

6. Check the abandoned borehole the next day to see if any settlement has occurred. If settlement has occurred, fill in the remaining space with grout, bentonite, concrete, or soil depending on the final use of the area and the amount of settling below grade.

7. Decontaminate all drilling equipment per SOP 6.

8. Ensure that the drilling subcontractor will fill out the “Water Well Sealing Report” and submit it to the Ohio Department of Natural Resources (ODNR). Fill out all relevant information in the log book and/or daily log.

Abandonment of a well (temporary or permanent) screened in more than one water bearing zone:

1. Before abandonment of the well, collect depth-to-water and total depth measurements in the monitoring well.

2. Have the drilling subcontractor remove any protective well materials such as a procasing or flush-mount, if applicable. These materials can be disposed of as municipal waste.

3. Have the drilling subcontractor slowly remove the well by applying an even upward force onto the riser pipe.

4. Once the well has been removed, have the drilling subcontractor create a borehole of at least the original diameter in which the boring was installed to a depth of the original total depth of the well.

5. At this point follow the steps listed in section VII “Abandonment of a soil boring”.

VIII. Data and Record Management

Information regarding the abandonment of boreholes and wells should be recorded in the field log book and/or daily log (SOP 18). If a well is abandoned, the drilling subcontractor is required to complete and submit a Well Abandonment Form to ODNR. In a scenario abandonment is completed on private property, copies of the form(s) should also be provided to the property owner.

IX. Quality Control and Quality Assurance

Copies of the completed well abandonment forms submitted to ODNR, should be acquired from the drilling subcontractor and checked for accuracy.

X. References

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, 2010. http://www.epa.state.oh.us/ddagw/tgmweb.aspx

Ohio Administrative Code 3745-9-07 and 3745-9-10.

Imagine the result

SOP 9

IDW Sampling

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for waste characterization sampling investigation-derived waste (IDW). The objective of this SOP is to describe the procedures to manage IDW, both hazardous and nonhazardous, which may be generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. IDW may include soil, groundwater, drilling fluids, decontamination liquids, personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials that may have come in contact with potentially impacted materials, will be collected and staged at a location designated as temporary waste storage. Waste materials will be analyzed for constituents of concern to evaluate proper disposal methods. PPE and disposable sampling equipment will be placed in DOT-approved containers prior to disposal. These items typically do not require laboratory analysis. This SOP describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly disposed. The procedures for handling IDW are based on the United States Environmental Protection Agency's Guide to Management of Investigation Derived Wastes (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical data indicates otherwise. IDW will be managed to ensure the protection of human health and the environment. Waste characterization sampling is performed so that the wastes can be disposed in accordance with applicable regulations.

II. Summary of Method

Waste characterization sampling involves the collection and laboratory analysis of composite samples of IDW.

III. Health and Safety Considerations and Cautions

Collecting samples of contaminated soil, water, sludges, etc., could pose health and safety concerns related to direct contact, ingestion, and/or inhalation. The site specific health and safety plan must be consulted before performing these activities.

IV. Interferences

When collecting IDW samples, a composite sample should be collected (see SOP 19). If this procedure is not followed, it is possible for a given sample to exhibit an artificially high or low concentration of given parameters. By following the sampling procedures closely, it is possible to obtain a representative sample of the waste for disposal.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site-specific required training, prior to engaging in any field activities.

VI. Equipment and Supplies

- Laboratory prepared and certified sample containers;
- Daily field log (example attached in Appendix B) or logbook;
- Sampling utensils;
- Stainless steel bowl;
- Socket wrench set;
- Hammer;
- Leather gloves;
- Nitrile gloves;
- Appropriate drum or container labels (outdoor waterproof self adhesive);
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as specified in the Chain-of-Custody SOP and Field Sampling Handling, Packing, and Shipping SOP (See SOP 2 and Appendix B);
- Indelible ink and/or permanent marking pens; and
- Bailer and rope (if sampling water).

VII. Sampling Procedure

NOTE: Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Testing In Progress, Hazardous, or Non-Hazardous);
- Waste generator's name (e.g., client name);
- Project name;
- Name and telephone number of ARCADIS project manager;
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%);
- Media (e.g., solid, liquid);
- Accumulation start and end date; and
- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

Sampling During a Subsurface Investigation

1. Samples should be collected and placed in a stainless steel bowl as the soil is being placed into 55-gallon drums during drilling activities. Soil cuttings placed in the stainless steel bowl should be randomly selected as to be representative of the entire boring.

2. Once the selected borings/subsurface work is completed, composite the samples collected in the stainless steel bowl, by gently mixing the soil.

3. Fill the appropriate IDW sample containers and place into an ice-filled cooler.

4. Record the sampling date, time, and sample identification in the field log book and/or daily log. Fill out the Chain-of-Custody which will accompany the sample to the laboratory.

5. Ensure that all the 55-gallon drums or other containers are appropriately labeled.

Sampling After a Subsurface Investigation

1. First, confirm the origin of the 55-gallon drums or containers containing IDW waste by checking the identification.

2. Open the selected 55-gallon drums or containers.

3. If the waste is a soil matrix, collect a sample from the 55-gallon drum or container. Place all the samples into the stainless steel bowl and mix gently to composite the sample (See SOP 19).

4. If the IDW is water, use a disposable bailer to collect a representative sample from the 55-gallon drums and/or poly tank.

5. Fill each of the sample containers with the composite soil or water sample.

6. Secure all 55-gallon drums, containers and/or poly tanks.

7. Correctly label the sample for laboratory analysis per SOP 2 and fill out all appropriate paperwork including the field logbook and/or daily log per SOP 18.

8. Once the data are received from the laboratory, ensure that the IDW is correctly labeled on the containers (i.e. remove “pending analysis” labels).

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically. Data received from laboratory analysis will be input and/or tabulated electronically.

All IDW will be documented as generated on a Drum/Container Inventory Log maintained in the field log book. The Drum/Container Inventory will record the generation date, type, quantity, matrix and origin of materials in every drum/container, as well as a unique identification number for each drum/container. The drum/container inventory will be used during drum/container pickup to assist with labeling of drums/containers. The drum/container storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

IX. Quality Control and Quality Assurance

If field forms and lab data is input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy. The chain-of-custody and sample labels for waste characterization samples will be filled out in accordance with the Quality Assurance Project Plan.

X. References

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

USEPA. 1991. Guide to Discharging CERCLA Aqueous Wastes to Publicly Owned Treatment Works (POTWs). Office of Remedial and Emergency Response. Hazardous Site Control Division 0S-220W. March 1991.

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SOP 10

Pneumatic Slug Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Michael Kladias

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for accurately completing a slug test using pneumatic pressure and pressure transducer to evaluate instantaneous change in head and recovery. This method may be used for permanent wells or temporary wells formed by the drilling pipe drop tube and temporary screen (SOP1). The purpose for this procedure is to provide uniformity of the method so that accurate measurements are always generated. The collection of accurate slug test data is critical for determining hydraulic conductivity.

II. Summary of Method

Pneumatic slug tests are conducted by sealing the permanent or temporary well head and applying air pressure to displace the groundwater level. As air pressure is increased in the well, the groundwater level falls until the water pressure and the air pressure return to equilibrium. After the groundwater level is stable, air is released from the sealed well head by opening an air release valve. The water level recovery is a rising head test and produces very high quality data with little interference. A pressure transducer is used to monitor and record the change of the groundwater level during the pneumatic slug test.

III. Health and Safety Considerations and Cautions

- For a permanent well, when unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).
- Care should be taken when sealing the well head assembly to the well casing or drop tube. The attachment should be very secure and air tight.
- When removing the well caps, there is potential for the release of vapors, the well must be off-gassed and the air must be monitored for vapors.
- The Health and Safety Plan should be reviewed before performing field activities associated with pneumatic slug tests.

IV. Interferences

If the groundwater is not allowed to equilibrate before a test is performed, an artificially high or low reading could be recorded. Allowing sufficient time for the groundwater to equilibrate will allow for accurate readings. The groundwater is equilibrated when the water level is stable. If the transducer is not decontaminated correctly between locations, it is possible for cross-contamination to occur. Follow decontamination procedures in SOP 7. Sufficient time needs to be allowed for transducer to equilibrate with the groundwater temperature to avoid instrument drift.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Field personnel are required to have sufficient knowledge and experience for completing slug testing.

VI. Equipment and Supplies

- Electronic water level meter;
- Vented pressure transducer;
- Laptop computer with appropriate software;
- Pneumatic slug test manifold;
- Field measurement log;
- Compressed nitrogen canisters with two stage regulator or air compressor with regulator and appropriate hoses;
- Decon equipment for transducer;
- Leak detection fluid;
- Teflon pipe thread sealant tape; and

- Plumbers putty or similar product.

VII. Pneumatic Slug Test Procedures

1. Measure water level (Refer to SOP 16).

2. Collect all field measurements on the supplied field form. Decontaminate the probe and tape (Refer to SOP 7).

3. Attach the pneumatic slug test manifold onto the top of the well casing. Tighten the rubber connector to ensure an airtight seal.

4. Lower transducer through the well casing and set below the static water level at a known distance. The transducer must be placed so that when the water level is depressed with air pressure the transducer will remain submerged below the water. Allow the transducer to cool to ambient groundwater temperature before zeroing and beginning the slug test to prevent any baseline drift. After cooling, raise the transducer just above the water level to zero at atmospheric temperature.

5. Place the transducer at the proper depth and mark the location where the transducer cable will be secured to the compression connector. Make a ball of plumbers putty at the marked location around the cable. Tighten by hand to seal the connection to the putty/transducer cable.

6. Attach transducer to the laptop computer running the appropriate software to conduct the slug test. The transducer should be set to record readings at 0.5 to 1 second intervals, shorter intervals of 0.5 seconds may be necessary for possible high hydraulic conductivity formations (> 10^{-2} cm/sec) determined by review of boring log (i.e. gravel) to properly record oscillatory responses. Start the data recording on the computer and pressure transducer.

7. Close the air release valve.

8. Open the inlet air valve with the pressure regulator closed.

9. Attach nitrogen/air supply to the fitting at the pressure regulator.

10. Slowly open the pressure regulator to pressurize well head and depress water level a sufficient distance without lowering the head below the top of the well screen. Larger distances may be needed for high-conductivity formations. Begin with a low pressure and gradually increase the pressure in order to obtain the desired water level and do not over pressurize the well (1 psi is equal to 2.3 feet of water).

11. Close inlet valve and leak check the system with leak detection fluid and on the pressure gauge and fix any leaks. If the leak is very slow or down the well, the regulator may be used to maintain a constant pressure head.

12. Check the transducer response and air pressure to verify system is stable. If it is stable proceed to the next step, if not check the seals.

13. Record the baseline pressure on the field form.

14. Quickly open the release valve to initiate the pneumatic slug test.

15. Allow sufficient time for water level to recover to static level. Slug test is complete.

16. Save files to a known location on the laptop computer prior to equipment disassembly.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms and saved on the laptop and flashcard for double backup.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

ASTM D 7242-06

Geoprobe® Pneumatic Slug Test Kit Standard Operating Procedure

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SOP 11

Low Flow Drawdown Test

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Kevin Wilson

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for completing a low-flow drawdown test using a pressure transducer and submersible pump to evaluate change in head from pumping at low-flow rates (less than 1000 milliliters per minute [mL/min]) and subsequent recovery. This method may be used for permanent wells or temporary wells (drilling pipe drop tube and temporary screen [SOP 1]). The purpose for this procedure is to provide uniformity of the method so that accurate measurements are always generated.

II. Summary of Method

Low-flow drawdown tests are conducted by pumping the permanent or temporary well at a low-flow rate of less than 1000 mL/min until a steady head is reached and maintained for approximately 15 minutes. The pumping rate may be adjusted during the test in order to maintain/achieve a maximum drawdown of approximately 20% of the initial water column or packed interval. After the completion of the initial pumping period, the pump will be shut off and recovery data will be recorded for approximately 15 minutes or until 90% recovery is achieved. A pressure transducer is used to monitor and record the change of the groundwater level during the low-flow drawdown test at 1 second intervals. Start and stop times, pump rates, and pump rate adjustment times will be recorded for each low-flow drawdown test. At the end of each test, groundwater level data will be downloaded from the pressure transducer to a field laptop computer, reviewed for data quality, and saved for later hydraulic conductivity analysis.

II. Health and Safety Considerations and Cautions

- For a permanent well, when unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).

- Care should be taken when sealing a packer in the drop tube. The attachment should be very secure and air tight.

- When removing the well caps, there is potential for the release of vapors, the well must be off-gassed and the air must be monitored for vapors.

- The Health and Safety Plan should be reviewed before performing field activities related to low-flow drawdown testing.

IV. Interferences

If the groundwater is not allowed to equilibrate before a test is completed. Allowing sufficient time (approximately 5 to 15 minutes) for the groundwater to equilibrate will allow for accurate readings. The groundwater is equilibrated when the water level is stable. If the transducer is not decontaminated correctly between locations, it is possible for cross-contamination to occur. Follow decontamination procedures in SOP 7. Sufficient time (approximately 5 minutes) needs to be allowed for transducer to equilibrate with the groundwater temperature to avoid instrument drift.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. Field personnel are required to have sufficient knowledge and experience for completing hydraulic testing.

VI. Equipment and Supplies

- Electronic water level meter;
- Vented or non-vented pressure transducer (pressure range of 35 feet/11 meters/15 psi);
- Laptop computer with appropriate software;
- Submersible pump with flow controller/meter;
- Field log; and
- Decon equipment for transducer, pump and electronic water level meter.

VII. Low-Flow Drawdown Test Procedures

1. Measure water level (Refer to SOP 13) or record packer depth.

2. Collect all field measurements on the supplied field log. Decontaminate the probe and tape (Refer to SOP 7).

3. Lower the submersible pump such that the intake of the pump is approximately at the middle of the saturated portion of the well screen and lower the transducer above the pump. Note: be certain not to exceed the maximum depth rating of the transducer.

4. Attach transducer to the laptop computer running the appropriate software. The transducer should be set to record readings at 1 second intervals. Start the data recording on the computer and pressure transducer.

5. Monitor the transducer to record sufficient background and ensure groundwater levels are steady for at least 5 minutes.

6. Turn on submersible pump and record flow rate and start time.

7. Monitor transducer output and adjust flow rate to maintain/achieve a maximum drawdown of approximately 20% of the initial water column and not exceed 1000 mL/min. If flow rate requires rates greater than 1000 mL/min, stop and communicate to field team leader. A pneumatic slug test may need to be completed.

8. If the well diameter permits, periodically check the drawdown manually using a water level indicator. Be certain to record these checks in the field log book.

9. Record flow rate adjustment times and flow rates.

10. After approximately 15 minutes, stop pump and monitor transducer output for 15 minutes or until 90% recovery is achieved. Record pump stop time.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms and saved on the laptop and flashcard for double backup.

IX. Data Analysis

The pumping test data will be analyzed using AQTESOLV® to estimate the hydraulic conductivities of each interval tested. AQTESOLV® assists in graphically and automatically matching type curves or straight lines to drawdown curves to solve empirical and partial differential equations describing fluid flow through a porous media. While a completely unique solution to each pumping test may not be possible, AQTESOLV can provide a range of solutions from which a relative hydraulic conductivity value can be determined.

X. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

XI. References

Robbins, G.A., A.T. Aragon-Jose, A. Romero, 2009. Determining Hydraulic Conductivity Using Pumping data from Low-Flow Sampling. Ground Water, Vol. 47, No. 2, p. 271.

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SOP 12

Installation of Groundwater Monitoring Wells

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) hydraulic conductivity testing of formations adjacent to the open interval of the well.

II. Summary of Method

Monitoring wells are installed to monitor discrete intervals within a hydrogeologic system. Drilling methods utilized for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, cable-tool, spun casing, sonic, dual-rotary (Barber Rig), hollow-stem auger, and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary, mud rotary, cable-tool, or sonic methods. The drilling method to be used will be selected based on site-specific consideration of anticipated drilling/well depths, site geology, type of monitoring to be conducted, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. All well construction materials will be new, re-used well materials will not be utilized. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- Well casing;
- Screen;
- Bentonite;
- Sand; and

- Grout.

III. Health and Safety Considerations and Cautions

There is direct-contact, ingestion, and inhalation concerns on sites where soil or groundwater is contaminated. Further, there are always physical hazards related to operation of a drill rig. The site-specific health and safety plan should be consulted prior to performing borehole or well installation activities.

IV. Interferences

The improper placement of the well screen could lead to a dry monitoring well. The primary concern when installing groundwater monitoring wells is to place the well screen across the appropriate interval within the water bearing unit.

- While drilling, care should be taken not to allow cross communication with significant water bearing units if possible. Properly placed casings and well seals should be used to prevent this communication.

- Well materials should be chosen which are compatible with any contaminants that may be encountered. Some materials (e.g. PVC) might dissolve over time when exposed to solvents in high concentrations.

- Well should be properly installed with correct well slot size vs. sand pack, surface infiltration; well seal; etc.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site specific required training, prior to engaging in any field activities.

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

VI. Equipment and Supplies

The following materials will be available by ARCADIS personnel during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- Personal protective equipment (PPE), as required by the HASP;
- Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- Appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- Soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- Appropriate sample containers and labels (see Appendix B);
- Drum labels as required for investigation derived waste handling;
- Chain-of-custody forms (see Appendix B);
- Insulated coolers with ice, when collecting samples requiring preservation by chilling;
- Photoionization detector (PID);
- Ziplock style bags;
- Water level or oil/water interface meter;
- Locks and keys for securing the well after installation;
- Decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels); and

- Daily Log and/or field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- Drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- Disposable plastic liners, when drilling with direct-push equipment;
- Well screen materials;
- Well riser materials;
- Well construction materials;
  - o Bentonite hole plug
  - o Appropriate-sized sand pack
  - o Well vault or pro-casing
  - o Cement
  - o Powdered bentonite
- Well construction/boring log, for ODNR;
- Weighted measuring tape;
- Drums/containers for investigation derived waste;
- Drilling and sampling equipment decontamination materials; and

- Decontamination pad materials, if required.

VII. Groundwater Monitoring Well Installation

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. The screened interval will be determine based on field observations, scope, and discussed prior to monitoring well installation.

3. Install the well to the total depth specified after conducting a soil boring investigation. No PVC Cements are to be used during the well construction.

4. Sound the bottom of the well with weighted measuring tape and subtract the portion of the well which is above the land surface (or add the distance from land surface to the top of the well casing if the well is below land surface) to determine if the well screen is being placed in the correct interval. If the boring is too deep and the annulus has not collapsed – fill void with bentonite chips to no more than 2 feet below depth of the bottom of screen. Hydrate chips and let rest for a sufficient amount of time for expansion– re-measure – fill remaining void with sand and set well in borehole.

5. Center well screen and casing in borehole.

6. Place the sand (or gravel) pack around the well screen and install to 2-feet above the well screen. Drill casing should be removed slowly during emplacement of the sand pack. Sound the sand pack top to confirm placement depth and record on well construction log. Sounding is completed to verify that the sand being placed does not “bridge” or create voids.

7. Pre develop well following SOP 13.

8. Place at least 3-feet of bentonite chips on top of the sand pack and hydrate the chips with potable water if above saturation. Drill casing should be removed slowly during emplacement. Care should be taken to ensure that

the chips do not bridge in the annulus between the well casing and the wall of the borehole. Let the hydrated chips rest for an extended period of time to allow sufficient expansion of the bentonite and record depth on well construction log.

9. Mix a cement/bentonite grout and install using a tremie-pipe to approximately 3 feet (frost line). Allow grout to settle for a sufficient amount of time.

10. Install a lockable protective pro-casing or flush mount well vault and secure in place with a concrete pad. Ensure that the cement extends to grout level just below frost line to prevent heaving.

11. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

12. During typical installation of steel pro-casings, bollards are placed around the well for protection. The bollards and casings should be painted with a bright color to increase visibility.

13. Label the well with the correct ID using a permanent method. Secure the pro-casing or well cap with a lock.

VIII. Data and Record Management

Drilling activities will be documented in a field notebook (SOP 18). Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features. The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed by a licensed surveyor in the state of Ohio. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. (Water Level measurement SOP 16). Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

IX. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original field logs to ensure accuracy.

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP 7.

X. References

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, 2010. http://www.epa.state.oh.us/ddagw/tgmweb.aspx

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SOP 13

Groundwater Monitoring Well Development

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for development of groundwater monitoring wells, used for water levels, hydraulic testing, and groundwater sampling. The method described below is for the predevelopment and development of wells through the use of a submersible pump (Ohio EPA, R.1, 2008).

When developing a well using the pumping method, the pump is lowered to the screened portion of the well. During purging, the pump is moved up and down the screened interval to remove fines including silt. Optionally, a surge block may also be used in addition to the pumping.

II. Summary of Method

The predevelopment of monitoring wells involves removing water from the drill casing before installing the sand pack and surging and removing water after the well and sand pack has been installed, but prior to casing removal and annual seal installation. The development of groundwater monitoring wells is completed to ensure the removal of all water related to the drilling process and fine materials (i.e. silt). The determination that formation water is entering the well is completed by monitoring the yield, groundwater chemistry, and turbidity. Development also ensures that the groundwater enters the well as readily as possible given the hydraulic properties and conditions of the producing formation. This process ensures the collection of a representative sample and accurate hydraulic testing results.

III. Health and Safety Considerations

There are specific health and safety concerns or cautions related to the development of groundwater monitoring wells: 1). repetitive motion with surging and setting the pump; 2). and there is direct-contact, ingestion, and inhalation concerns on sites where groundwater is contaminated. Further, there are physical hazards related to operation of a groundwater pump. The site-specific health and safety plan should be consulted prior to performing well development activities.

IV. Interferences

The presence of non-aqueous phase liquids (NAPL) could be encountered during the drilling and well installation process. If NAPL is present, measures should be taken for recovery and surging should not take place to prevent smearing across formation.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses, as well as any site-specific required training, prior to engaging in any field activities. Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

VI. Equipment and Supplies

- Monitoring well keys;
- Bailers (dedicated or disposable) in the scenario in which NAPL is present;
- Submersible Pump with Controller;
- Tubing (disposable or dedicated);
- 12 volt DC power source,(i.e. generator or battery);
- Graduated pails or containers;
- Purge water tank or drum;
- Electronic Water Level Meter (Oil Water Interface probe, if applicable);
- Water Quality Meter; and
- Daily Log and/or field book (see Appendix B).

VII. Groundwater Monitoring Well Predevelopment

1. When drill casing is at the total well depth, check for NAPL (SOP 17).

2. If NAPL is present, recover as much as possible using a disposable bailer.

3. If NAPL is not present, then calculate the volume of water in the casing and then remove the water from casing using a submersible pump. If the casing recharges as much as the pumping rate – remove at least one well volume.

4. Install the well, well sand pack according to SOP 12.

5. Before installing the filter pack and annular seal with the casing still at the top of the sand pack at depth, lower a submersible pump and follow steps 6 through 8 (do not raise and lower pump across the well screen if NAPL is present).

6. Removal at least three well volumes.

7. Check depth of sand pack to make sure settling has not occurred.

8. If the sand pack has settled, then add additional sand to the proper level.

9. Continue with well installation.

VIII. Groundwater Monitoring Well Development

NOTE: Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

1. The monitoring well must have been installed 48 hours prior to development for proper cure of the annular seal.

2. Check for the presence of NAPL (SOP 17).

3. If NAPL is present, recover as much as possible using a disposable bailer and in Step 7 – do not raise and lower pump across screen.

4. Measure depth to water and total depth and calculate well volume.

5. Ensure pump is clean, if not decontaminate pump (SOP 7).

6. Attach pump to tubing and lower pump to the approximated depth of the top of screen.

7. Lower the pump down the screen and repeat in reverse raising the pump to the top of the screen until groundwater becomes less turbid if not already clear. During this process start the pumping at a low rate (about 100 to 200 mL/min) and increase to at least 10 times towards the end.

8. If the turbidity does not improve – increase the pumping rate.

9. Continue pumping taking the below groundwater quality measurements every well volume (following modified table from Ohio EPA).

Parameter	Stabilization
pH	± 0.1
Specific Conductance	± 3%
Temperature	± 1º C
Turbidity	± 10% (when turbidity is greater than 10 NTUs)
Oxidation-Reduction Potential (ORP)	± 10 mv
Dissolved Oxygen (DO)	± 0.3 mg/L

10. The well is properly developed when the above parameters have stabilized over three well volumes and sediment in well is ≤0.1 feet.

11. If the well goes dry, stop pumping immediately. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping when sufficient water has recharged the well.

12. If the parameters have not stabilized, then the well is considered developed when:

    - another method is tried,
    - well construction is verified to be correct,
    - turbidity is within ±10% over 3 successive well volumes,
    - conductivity and pH have stabilized, and
    - sediment in well is ≤0.1 feet.

IX. Data and Record Management

Well development activities will be documented in a proper field notebook (SOP 18). Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

X. Quality Control and Quality Assurance

After the completion of the electronic logs they will be compared to the original field logs to ensure accuracy.

XI. References

Ohio EPA, Technical Guidance Manual for Hydrogeology Investigations and Ground Water Monitoring, 2010. http://www.epa.state.oh.us/ddagw/tgmbew.aspx

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SOP 14

Low Flow Sampling

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and collect groundwater samples. Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter.

II. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities. All personnel are also required to have experience with groundwater sampling by low-flow methodology.

III. Equipment List Specific to this activity, the following materials (or equivalent) will be available:

- Site Plan, well construction records, prior groundwater sampling records (if available).
- Sampling pump, which may consist of one or more of the following:
  - Submersible pump,
  - Peristaltic pump, or
  - Bladder pump.
- Appropriate controller and power source for pump;
- Tubing;
- Electronic Water-level meter;
- Water-quality (temperature/pH/specific conductivity/ORP/dissolved oxygen) meter and flow-through measurement cell;

- Appropriate water sample containers (supplied by the laboratory);
- Appropriate blanks (trip blank supplied by the laboratory);
- 0.45-micron disposable filters (if field filtering is required);
- Decontamination equipment (SOP 7); and
- Groundwater sampling log (Appendix B).

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers.

VI. Procedure

1. Calibrate field instruments according to manufacturer procedures for calibration.

2. Measure initial depth to groundwater prior to placement of pumps (SOP 16).

3. Prepare and install pump in well: Slowly lower pump, tubing, and leads into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of tubing and leads while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

4. Connect the pump to other equipment. If using a bladder pump, the discharge water line should be connected to the bottom inlet port on the flow-through cell connected to the water quality meter. Connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin

the gas flow. Turn on the pump controller if an on/off switch is present and verify that all batteries are charged and fully operating before starting pump.

5. Measure the groundwater level again (SOP 16) with the pump in the well before starting the pump. Start pumping the groundwater at 200 to 500 milliliters (mL) per minute. The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement) and the water level should stabilize. The water level should be monitored every 3 to 5 minutes during pumping if the well diameter is of sufficient size to allow such monitoring. Care should be taken not to break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to groundwater. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition. If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

   During purging, monitor the field indicator parameters (e.g., temperature, specific conductance, and pH) every 3 to 5 minutes (or as appropriate). Field indicator parameters will be measured using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log (SOP 18). The well is considered stabilized and ready for sample collection when the specific conductance and temperature values remain within 3%, and pH remains within 0.1 units for three consecutive readings collected at 3- to 5-minute intervals. If the field indicator parameters do not stabilize within 30 minutes of the start of purging the well can be sampled.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

6. Complete the sample label and cover the label with clear packing tape to secure the label onto the container (SOP 2).

7. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others.

8. If sampling for total and filtered metals, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of “flush” water has been run through the filter in accordance with the manufacturer’s directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container. When the container is full, tightly screw on the cap.

9. Secure with packing material and store at 4°C in an insulated transport container (SOP 2).

10. Record on the groundwater sampling log or bound field logbook or PDA the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Appendix B).

11. Turn off the pump or air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing and leads from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.

12. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.

13. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

14. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody (SOP 2).

15. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate (SOP 7).

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client.

VIII. Data Recording and Management

Field logs or PDA files and chain-of-custody records will be transmitted to the ARCADIS TM/PM at the end of each day unless otherwise directed by the TM/PM.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.
- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well) see SOP 15.
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook (SOP 2).
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination (SOP 7).

IX. Quality Control and Quality Assurance

Duplicate groundwater samples will be collected a rate specified in the QAPP to ensure accuracy when sampling.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA Region II. 1998. Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling.

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SOP 15

Equipment Blank Collection

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for collecting equipment blanks, sometimes referred to as rinse blanks, which are used for validated data collected using non-disposable sampling equipment. If disposable and/or dedicated sampling equipment is used, this SOP is not applicable as it is assumed that there is no chance for cross-contamination between sampling locations and samples.

II. Summary of Method

Equipment blanks are collect by rinsing decontaminated, no-dedicated sampling equipment with laboratory grade deionized (DI) water, collecting the rinse water in sample containers, and submitting the samples for laboratory analysis. The resulting data are used to validate samples collected during a given environmental investigation.

III. Health and Safety Considerations and Cautions

Care should be taken when handling sample containers with preservatives which could be harmful. Preserved containers could off-gas when opened and/or be caustic. Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions. Appropriate personal protective equipment (PPE) must be worn by all field personnel within the designated work area.

IV. Interferences

If the equipment to be used is not correctly decontaminated, the equipment blank sample could indicate the presence of contaminates. This could lead to questionable data collected during a given field program.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any required site specific or client training requirements. ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

VI. Equipment and Supplies

The following materials will be available, as required, when collecting equipment blank samples:

- Decontaminated sampling equipment (SOP 7),
- Laboratory grade DI water,
- Appropriate sample containers and forms,
- Daily Log and/or field notebook (Appendix B); and
- Nitrile gloves.

VII. Equipment Blank Sampling Procedures

Equipment blank from a split-spoon sampler

1. Ensure that the split-spoon sampler has been appropriately decontaminated.
2. Don clean nitrile gloves.
3. Set the equipment up so that it will be possible to pour the laboratory grade DI water down the center of the inside of the split-spoon sampler, or other deconned equipment, and into the laboratory prepared sample containers.
4. Slowly pour the laboratory grade DI water down the center of the inside of the split-spoon and into the sample container.
5. Once the sample container is filled, seal the sample and label it with the appropriate ID, time, date, and requested analysis.
6. Place the sample in an ice-filled cooler and fill out the sampling information in the daily log and/or logbook. In addition, the Chain-of-Custody should be completed with the appropriate sample information (SOP 2).

Repeat steps 1-6 above, as necessary, with additional non-dedicated sampling equipment at the frequency prescribed in the Quality Assurance Project Plan (QAPP).

VIII. Data and Record Management

Sample identification, equipment used (if appropriate), sample date and time will be recorded in the field notebook, and/or the boring log (SOP 17). The sample will also be identified on an appropriate chain-of-custody form, for submittal to an analytical laboratory for analysis.

IX. Quality Control and Quality Assurance

Equipment blanks will be collected on the interval as set forth in the QAPP. After the equipment blank sample data is received from the laboratory, it will be reviewed and used for data validation purposes.

X. References

None.

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SOP 16

Water Level Measurements

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

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Approval Signatures

Prepared by: ____________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ____________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ____________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for accurately measuring the depth to water in a monitoring well and the total depth of a monitoring well using an electronic water level meter. The purpose of this procedure is to provide uniformity of method so that accurate water level data are always generated. The collection of accurate water level and total depths is critical for determining the center of well screens and the direction of water flow.

II. Summary of Method

Water level and total depth measurements are collected using an electronic water level probe attached to a tape graduated in hundredths of feet.

III. Health and Safety Considerations and Cautions

- Care should be taken when lowering and removing the water level meter from the well as to not run the tape along a jagged surface, doing this could lead to removal of the insulation around the tape and create a short circuit in the meter rendering it useless.

- Prior to unlocking the pro-casing or flush-mount, the well should be inspected for stinging/biting insects (e.g. wasp nests).

- When removing the well caps, there is potential for the release of harmful vapors, the well should be off-gassed using a pressure release valve, if installed, and the air should be monitored for potential harmful landfill gases. The site-specific health and safety plan must be reviewed before performing field activities.

IV. Interferences

- If the groundwater is not allowed to equilibrate before a reading is measured an artificially high or low reading could be recorded. Allowing sufficient time for the water to equilibrate will allow for accurate readings.

- If the water level meter is not decontaminated correctly between wells it is possible for cross-contamination to occur.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any site-specific training prior to engaging in field activities.

VI. Equipment and Supplies

- Electronic water level meter,
- Water sampling log and/or depth to water form (Appendix B),
- Daily Log and/or field logbook (Appendix B); and
- Decontamination equipment.

VII. Water Level Measurement Procedures

1. Check that the water-level indicator battery is functional.
2. Decontaminate the probe and tape (Refer to SOP 7).
3. Ensure that the monitoring well to be measured is correctly identified.
4. Remove cap from well and check for the reference mark. Allow sufficient time for groundwater within the well to equilibrate to atmospheric pressure.
5. Slowly lower the probe into the center of the well until a contact with the groundwater surface is indicated, either by audible alarm and/or light, and note depth measurement to 0.01 feet from the reference mark.
6. Mark and hold the tape at the contact point and repeat the measurement to ensure groundwater has equilibrated.
7. Turn off the power and sound the well (i.e., lower the tape to the bottom of the well). Record the depth to 0.01 feet.

8. Retract the tape by winding onto the spool, wiping with a disposable paper towel with distilled water as it comes out of the well. Decontaminate the retracted tape and probe (SOP 7).

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

None.

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SOP 17

NAPL Measurements

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

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Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is for accurately measuring the thickness of light NAPL (LNAPL) and the thickness of dense NAPL (DNAPL) in a monitoring well. The purpose of this procedure is to provide uniformity of method so that accurate NAPL thickness data are always generated and that correct intervals are targeted for sampling or well construction. In addition, because this SOP describes water-level measurement from surveyed measurement points, this SOP can be followed, to obtain water level measurements from surveyed measurement points on the monitoring wells.

II. Summary of Method

Measurements to depth to products, water levels, and total depths in wells which exhibit NAPLs are collected by lowering an oil-water interface probe with a tape graduated in hundredths of feet.

III. Health and Safety Considerations and Cautions

When opening the wells they should be vented first to allow any gases to escape.

- Care should be taken when lowering and removing the oil-water interface probe from the well as to not run the tape along a jagged surface, doing this could lead to removal of the insulation around the tape and create a short circuit in the meter rendering it useless.

- The oil-water interface probe should be grounded because the NAPL is typically flammable and/or explosive.

IV. Interferences

- If the water is not allowed to equilibrate before a reading is collected an artificially high or low reading could be recorded if there is a vacuum in the well. Allowing sufficient time for the water to equilibrate will allow for accurate readings.

- If the water level meter is not decontaminated correctly between wells it is possible for cross-contamination to occur.

- The oil/water interface probe can become coated with LNAPL, leading to an artificial thickness reading.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course, associated 8-hour refresher courses, and the any site-specific required training prior to engaging in any field activities. Individuals conducting fluid level measurements will have been trained in the proper use of the instruments, including their use for measuring fluid levels and the bottom depth of wells.

VI. Equipment and Supplies

- Oil-water interface probe;
- Photoionization Detector (PID);
- Any appropriate PPE as required by the Site Specific HASP;
- Water sampling log and/or depth to water form (Appendix B);
- Daily Log and/or field notebook (Appendix B); and
- Decontamination equipment.

VII. Measurement Procedures

The detailed procedure for obtaining fluid level depth measurements is as follows. Field notes on logs will be treated as secured documentation and indelible ink will be used. As a general rule, the order of measuring should proceed from the least to most contaminated monitoring wells, based on available data

1. Check that the oil-water interface battery is functional.
2. Decontaminate the probe and tape (SOP 7).
3. Ensure that the well to be measured is correctly identified.

4. Unlock well, vent cap by releasing the pressure valve, remove cap and let stand until water equilibrates in the well. Monitor concentrations of the gases in the well with appropriate air monitoring equipment and record the values on the daily field log and/or log book and the water sampling log.

5. Allow sufficient time for groundwater within the well to equilibrate to atmospheric pressure.

6. Locate a measuring reference point on the well casing. If one is not found, initiate a reference point at the highest discernable point on the inner casing (or outer if an inner casing is not present) by notching with a hacksaw, or using an indelible marker. All down-hole measurements will be taken from the reference point established at each well on the inner casing (on the outer only if an inner casing is not present.

7. Lower the probe into the center of the well until a contact with the LNAPL (typically a solid beep) or water surface (typically an intermittent beep) is indicated, either by audible alarm or light, and note depth to 0.01 feet.

8. Mark and hold the tape at the contact point and repeat the measurement.

9. If LNAPL is encountered (Step 5), continue to slowly lower the probe until water is contacted (typically indicated by change from intermittent to a solid beep). Calculate and record the thickness of the LNAPL. It should be noted that this can be difficult due to the fact that the LNAPL might coat the probe.

10. Continue to slowly lower the probe through the water column until DNAPL is detected (typically indicated by a change back to intermittent beep) or until the bottom of the well is reached.

11. If DNAPL is encountered, continue to slowly lower the probe until the bottom of the well is reached. Record the depth of the bottom of the well to 0.01 feet. Calculate and record the thickness of DNAPL.

12. Turn off power and retract the tape by winding onto the spool, wiping with a disposable paper towel with distilled water as it comes out of the well.

Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.

If field forms are input or tabulated electronically after the field program, they should be compared to the original field forms to ensure accuracy.

VIII. Data and Record Management

The information collected should be recorded on the appropriate forms. When appropriate, this recorded data will be input and/or tabulated electronically.

IX. Quality Control and Quality Assurance

If field forms are input or tabulated electronically after the field program they should be compared to the original field forms to ensure accuracy.

X. References

None.

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SOP 18

Field Book Entry Procedures

RACER

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

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ARCADIS

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) covers the entries needed in a field log book for environmental investigations. This SOP does not address all of the entries that may be needed for a specific project, and does not address health and safety, equipment decontamination, field parameter measurements, sample preservation, chain-of-custody, or laboratory analysis.

II. Summary of Method

This SOP will assist field personnel in identifying the proper procedures need to document activities needing recorded during a field investigation.

III. Health and Safety Considerations and Cautions

Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions.

IV. Interferences

Poor handwriting can lead to misinterpretation of written information, as best as practical, care should be taken when handwriting data. Where possible and appropriate, electronic data capturing devises should be considered.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any required site specific or client training requirements.

VI. Equipment and Supplies

- Daily log and/or field log book.

- Ball point (medium point) pen with blue or black ink. A fine point Sharpie pen may be used if the ink does not bleed through the page and become visible on back side of the page. If weather conditions prevent the use of a pen, indicate so in the log and use an alternate writing instrument. A write-in-the-rain™ pen can also be utilized in adverse weather conditions.

- Zip-lock baggie or other weather-proof container to protect the field log book from the elements.

VII. Field Log Book Entry Procedures

- Print legibly. Do not use cursive writing.
- The name of the project, project number and project location should be written in indelible ink on the outside of the field log book.
- On the inside of the front cover, write "If Found, Please Return to ARCADIS" and include the appropriate address and phone number, the name of the person to which the book is assigned, and the name of the project manager.
- Reserve the first page of the book for a Table of Contents.
- Reserve the last five (5) pages of the book for important contacts, notes, reminders, etc.
- Each day of field work, the following should be recorded in the field log book as applicable:

  a) Project Name.

  b) Date and time arrived.

  c) Work Site Location.

  d) Names of people on-site related to the project including ARCADIS employees, visitors, subcontractor employees, agency personnel, client representative, etc.

  e) Describe the work to be performed briefly, and list the equipment on-site.

  f) Indicate the health and safety (H&S) level to be used.

  g) Record instrument calibrations and checks.

  h) Record time and general content of H&S briefing.

i) Describe the weather conditions, including temperature, precipitation, and wind speed and direction.

j) List periodic time entries in the far left hand column of each page.

k) Minimize unused space on each page.

- The tailgate meeting must be recorded in the log book and the tailgate form completed (see HASP). If health and safety monitoring is performed, record the time and results of initial and follow-up monitoring.

- Note factual observations including collection of QA/QC samples, delays, well damage, accidents, work plan deviations, instrument problems, and problem resolutions.

- Describe work performed and how documented such as photographs, sample core logs, water sampling logs, etc.

- Describe bases for field decisions including pertinent conversations with visitors, regulators, or project personnel.

- Note final instrument calibrations and checks.

- Sign the log book at the end of each day at a minimum. Draw a line to the end of the page to indicate no further entries on that page. Sign and date the bottom of each page if possible.

- If an entry to the log book is changed, strike out the deleted text or item with a single line such that the entry remains legible, and initial and date the change. Such changes should only be made by the same person that made the initial entry.

- Field log book entries must be made in the field at the site, not at a later time at a different location. Supplemental entries to the log book may be made at a later date. The supplemental entry must be clearly identified as such and the entry must be signed and dated as described in this SOP.

- Problems noted in the field log book must be brought to the attention of the project manager and task manager in a timely fashion. Problems may be reported in person, on the telephone, or in a written daily log form. If daily logs are prepared and you will not be able to personally give the daily log to the project manager, send the daily log via FAX or overnight courier to the project manager and task manager.

VIII. Data and Record Management

Each page of the field log book should be scanned for electronic/digital archiving at periodic intervals. This will ensure that copies of the field notes are available in the event the field book is lost or damaged, and that field data can be easily disseminated to others without the risk of physically sending the field log book. Field log books that are full should be archived with the project files, and readily retrievable.

IX. Quality Control and Quality Assurance

None.

X. References

None.

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SOP 19

Compositing or Homogenizing Samples

Motors Liquidation Company

Moraine, Ohio

Rev. #: 0.0

Rev Date: November 5, 2010

This SOP was included in the Pre-Design Investigation Work Plan that was approved by the U.S. EPA on June 1, 2012.

Approval Signatures

Prepared by: ______________________ Date: November 5, 2010
Trey Fortner

Reviewed by: ______________________ Date: November 5, 2010
Joseph Rumschlag

Approved by: ______________________ Date: November 5, 2010
Jason Manzo

I. Scope and Application

This standard operating procedure (SOP) is to be used when composting/homogenizing solid and semisolid samples as outlined below.

II. Summary of Method

This SOP will assist field personnel in identifying the proper procedures need to composite solid or semi-solid samples for analysis.

III. Health and Safety Considerations and Cautions

Refer to the project Health and Safety Plan for any site-specific procedures or instructions for responding to Site conditions. Appropriate personal protective equipment (PPE) must be worn by all field personnel within the designated work area. Air monitoring may be required during certain field activities as required in the Site Health and Safety Plan.

IV. Interferences

- The field crew must be aware of the potential chemicals of concern (COCs), and equipped with a variety of sample homogenizing equipment. The field crew must take care not to use equipment that may react with suspected COCs. For example, stainless steel implements should not be used to homogenize strongly acidic materials.

- Soil, sediment, sludge and other solid/semisolid materials that are easily mixed should be thoroughly homogenized. Excessive, vigorous mixing should be avoided as COCs can be mobilized/liberated posing a health and safety risk and diminishing the representativeness of the sample.

- Implements used for compositing/homogenizing should be thoroughly decontaminated between samples. A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of equipment/supplies that are to be shipped.

V. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities along with any required site specific or client training requirements. ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

VI. Equipment and Supplies

The following materials will be available, as required, when compositing or homogenizing samples:

- Personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- Stainless steel, plastic, glass or ceramic spoon (or disposable equivalent);
- Stainless steel, plastic, glass or ceramic bowl (or disposable equivalent);
- Stainless steel, plastic, glass or ceramic jar/bottle (or disposable equivalent);
- Shovel or trowel;
- Decontamination supplies;
- Digital camera;
- Appropriate sample containers and forms; and
- Field notebook.

VII. Field Log Book Entry Procedures

Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample. The procedure for mixing samples is provided below:

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless steel spoon (or disposable equivalents). When dealing with large sample quantities, use disposable plastic sheeting and a shovel or trowel. Note: When preparing samples for metals analyses, do

not use disposable aluminum (or metal tools or trays other than stainless steel), as it may influence the analytical results.

2. Flatten the pile by pressing the top without further mixing.

3. Divide the circular pile by into equal quarters by dividing out two diameters at right angles.

4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting.

5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite or homogenous sample.

6. Place composite or homogenized sample into specified containers. Remaining material will be disposed of in accordance with project requirements and applicable regulations.

VIII. Data and Record Management

Sample identification, interval depth (if appropriate), sample date and time will be recorded in the daily log or field notebook, and/or the boring log. The sample will also be identified on an appropriate chain of custody form, for submittal to an analytical laboratory for analysis. Consider digital photography to record unusual field conditions or to document compliance (i.e. proper labeling and storage of drums/IDW containers).

IX. Quality Control and Quality Assurance

All materials to be re-used for sample compositing/homogenizing will be decontaminated as appropriate.

X. References

None.

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SOP 20

Sub-Slab Soil-Gas Point Installation and Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 10, 2011

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: ____________________ Date: July 7, 2010
Mitch Wacksman

Approved by: ____________________ Date: July 7, 2010
Christopher Lutes

Modified by: ____________________ Date: Revised, February 10, 2011
Mitch Wacksman

Modified by: ____________________ Date: Revised, December 3, 2010
Joseph Rumschlag

I. Scope and Application

This document describes the procedures for installing permanent sub-slab sampling points and collecting soil-gas samples using permanent points. Samples from the points are collected in an evacuated 1-liter SUMMA®-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of permanent sub-slab soil-gas points and the collection of sub-slab soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For sub-slab soil-gas point installation, drilling with an electric concrete impact drill should be completed only by personnel with prior experience using such a piece of equipment and with the appropriate health and safety measures in place as presented in the JLA. It is possible to encounter high concentrations of VOCs in sub-slab soil-gas, so the amount of time the borehole remains open should be minimized. For the same reason, when installing sub-slab points in spaces with minimal dilution potential, such as closets, it may be necessary to provide local ventilation. Finally, sub-slab point installation should be completed after any indoor air sampling to avoid cross contamination of the indoor air samples.

IV. Equipment List

The equipment required to install a permanent sub-slab soil-gas point is presented below:

- Appropriate personal protective equipment (PPE; as required by the site specific HASP and the JLA)
- Electric hammer drill (e.g., Bosch®, Hilti®, etc.);
- 5/8-inch and 1 1/2-inch diameter concrete drill bits for impact drill (drill bit length contingent on slab thickness);
- Decontaminated soil-gas point (typically 3-inch stainless steel pipe 9/16-inch OD [1/4-inch NPT threads on one end], 1/4-inch NPT female coupling, stainless steel Swagelok® fitting (or similar) bored through male connector [1/4-inch tube OD x 1/4 inch male NPT]), and stainless steel Swagelok® (or similar) plug for 1/4-inch tube fitting;
- Extra 1/4-inch Swagelok® front and back compression sleeves;
- Tubing cutter with heavy-duty cutting wheel;
- Hand tools, including open-end wrench (typically 9/16-inch), pliers, Channel Lock® pliers, etc.;
- Teflon® tape;
- Quick-setting non-shrink grout powder;
- Modeling clay (VOC free and non-drying);
- Potable water for mixing grout;

- Disposable cups and spoons for mixing grout;
- Spray bottle with potable water;
- Broom and dust pan;
- Paper towels;
- Nitrile gloves;
- Work gloves;
- Knee pads;
- Bottle brush;
- Ground fault circuit interrupter (GFCI);
- Extension cords capable of amperage required for hammer drill;
- Plastic sheeting; and
- Shop vacuum with clean fine-particle filter

The equipment required for sub-slab soil-gas sample collection is presented below:

- 1-liter stainless steel SUMMA® canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g.,30 minutes) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch OD Teflon® tubing;
- 1/4-inch Swagelok® by 1/8-inch NPT male stainless steel coupling;
- Extra 1/4-inch Swagelok® front and back compression sleeves;

- Decontaminated stainless steel Swagelok® or comparable "T" fitting and needle valve for isolation of purge pump;
- Stainless steel duplicate "T" fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);
- Portable vacuum pump capable of producing very low-flow rates (e.g., 50 to 200 mL/min);
- Electric flow sensor (Bios DryCal® or equivalent);
- Tracer gas testing supplies (refer to "Administering Tracer Gas" SOP #21);
- Appropriate-sized open-end wrench (typically 9/16-inch and 1/2-inch);
- Tedlar® bag to collect purge air or length of tubing sufficient to vent it outside the structure;
- Compound pressure/vacuum gauge;
- Portable weather meter, if appropriate;
- Chain-of-custody (COC) form;
- Sample collection log (attached);
- Nitrile gloves;
- Work gloves;
- Field notebook.

V. Procedure

Permanent Sub-Slab Soil-Gas Point Installation

Permanent sub-slab soil-gas points are installed using an electric drill and manual placement of the sub-slab point. After a dry fit, the sub-slab point is inserted into the hole and grouted with a quick-setting, non-shrink grout powder. The soil-gas point is equipped with a plug. The plug is removed and a compression fitting nut and ferrules are used to allow collection of a sub-slab soil-gas sample through Teflon® tubing. The sub-slab point and tubing will be purged with a portable sampling pump prior to collecting the sub-slab soil-gas sample. Detailed installation methods are as follows:

1. Complete utility clearance in accordance with ARCADIS Utility Locate SOP with assistance from Ohio Utility Protection Service (OUPS) prior to drilling activities.

2. Assemble the sub-slab sample point assembly. Teflon® tape should never be used with Swagelok® connections; it should be used on normal NPT threads.

3. Remove, only to the extent necessary any covering on top of the slab (e.g., carpet).

4. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

5. Advance the 1 1/2-inch drill bit approximately 2 1/2 inches into the slab. This hole is drilled deep enough to permit the top of the sampling point to be set flush with the slab when the 1/4-inch tubing (9/16-inch OD) is inserted into the 5/8-inch hole drilled under Step 6, below. Clean up cuttings with shop vacuum, bottle brush, and dust pan.

6. Drill a 5/8-inch-diameter hole into the concrete slab using the electric drill. Do not fully penetrate the slab at this time. Stop drilling approximately 1 inch short of penetrating the slab. To gage this, a typical concrete slab is 4-6 inches thick. Therefore, stop drilling at 3 inches.

7. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

8. Advance the 5/8-inch drill bit the remaining thickness of the slab and approximately 3 inches into the sub-slab material to create an open cavity.

   Note (if possible) from the drill cuttings any evidence for the types of materials in the immediate sub-slab – i.e. moisture barriers, sand, gravel, etc.

9. Use the bottle brush, whisk broom, and dust pan to quickly clean material around and within the hole. The hole should not be left open for any extended length of time to ensure that VOCs below the slab do not migrate into indoor air (plug with clay during clean up). Do not use the shop vacuum to clean up the drill hole after the full thickness of the slab has been penetrated.

10. Using an assembled sub-slab point, test fit the components so that the proper length of 1/4-inch tubing and depth of the 2 1/2-inch hole provides enough space for the coupling. Adjust so that the sample port plug will lie flush with the slab surface and does not create a tripping hazard.

11. If necessary, re-drill the 5/8-inch hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing, or even a piece of heavy wire (e.g., coat hanger).

12. Wrap the sample point assembly with Teflon® tape or VOC free modeling clay, to the extent necessary, for a snug fit of the assembly into the 5/8-inch diameter hole and also to prevent migration of cement to the sub-slab. Ensure that Teflon® tape or modeling clay do not interfere with the cement that will be used to permanently fix and seal the sample point.

13. Prepare a mixture of VOC-free non-shrink quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

14. Before cementing in the sub-slab point, moisten the 1 1/2-inch drill hole with the spray bottle to provide better adhesion.

15. Cement in the sub-slab point using the plastic spoon to apply the cement into the annular space between the coupling and the 1 1/2-inch drill hole.

16. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent point.

17. Proceed to sub-slab soil-gas sample collection after waiting a minimum of 24 hours for equilibration following sub-slab point installation.

Sub-Slab Soil-Gas Sample Collection

Once the permanent sub-slab point is installed, the following procedures should be used to collect the sample in a SUMMA® canister:

1. Record the following weather information from inside the building being sampled in the field notebook:

    a. wind speed and direction (if capable with in-field measuring device);

    b. ambient temperature;

    c. barometric pressure; and

    d. relative humidity.

2. Before sampling, remove the sample point plug and attach a compound pressure/vacuum gauge to the end of the sample point to record the pressure gradient occurring between indoors and sub-slab. Record the positive or negative pressure reading in the field notebook. Cap the sample point once the reading is collected.

3. Check all SUMMA®-type canisters for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

4. Remove the brass plug from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister. Record in the field

notebook and COC form the flow controller number with the appropriate SUMMA® canister number.

5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA® canisters using stainless steel Swagelok® duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.

6. Complete a “shut in” or “leak down” test prior to sampling each sub-slab soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA® canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA® canister will be placed on the end of the sample train, effectively producing a closed system. The SUMMA® canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively “shut-in” to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.

7. Connect a Swagelok® (or comparable) T-fitting to the end of the sample tubing. On one end of the T-fitting connect a short length of Teflon® tubing to the assembled sample train (flow control with in-line particulate filter and vacuum gauge and SUMMA® canister). On the other end of the T-fitting connect a Swagelok® (or similar) two-way valve using a short length of 1/4-inch OD Teflon® tubing.

8. Connect the two-way valve and the properly calibrated portable vacuum pump using a length of tubing. Affix a Tedlar® bag to the purge pump to capture all purged air. The purged air should be evacuated outside the building.

9. Purge 3 volumes of air from the sub-slab soil-gas point and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing and sample point using the calculation:

$$V_1 + V_2 = V_t$$

where:

$V_1 = \pi r^2 h$ = open space volume of sample tubing

$V_2 = \pi r^2 h$ = open space volume of sample point
V_t = total volume

r = inner radius of sample point or sample tubing

h = height of sample point or length of tubing

10. A tracer-gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around all sub-slab soil-gas points and connections by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP 21 “Administering Tracer Gas,” for procedures on tracer gas use.] If unacceptable leaks are detected ($\geq$ 5% of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement sub-slab point should be installed and sampled. Measure organic vapor and tracer gas levels within the Tedlar® bag, as appropriate

11. Close the two-way valve to isolate the purge pump.

12. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

13. On a floor plan or sketch of the area being sampled, include the following information:

    - Sample location;
    - Locations of heating, ventilation, and air conditioning equipment;
    - Chemical storage areas;
    - Any attached garages or utility areas;
    - Doorways and stairways;

- Any sumps, drains, or other utility perforations;
- Separate footings sections or buildings constructions; and
- The nearest street and the direction of north.

14. Take a photograph of the SUMMA® canister and surrounding area unless prohibited by the building owner.

15. Check the SUMMA® canister approximately half way through the sample duration and note progress on sample logs.

Termination of Sample Collection

1. Due to the short duration of sampling, field staff should stay with the SUMMA® canister throughout sampling.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Disconnect sample tubing from the sample point and replace flush-mount cap.

5. Remove the particulate filters and flow controllers from the SUMMA® canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.

6. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canisters should <u>not</u> be preserved with ice or refrigeration during shipment.

7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.

9. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent sample point. Document with photographs.

Decommissioning of Permanent Sub-Slab Soil-Gas Points

1. Remove, only to the extent necessary any covering on top of the permanent sample point (e.g., carpet).

2. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

3. Using a hammer, carefully strike the sample point on the top of the plug to dislodge the permanent point from the slab. Repeat until the sample point becomes loose inside the borehole.

4. Remove the sample point from the slab.

5. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

6. Prepare a mixture of VOC-free, non-shrink, quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

7. Place cement in 11/2-inch borehole using the plastic spoon until the hole is filled and wait until the cement sets.

8. Replace the surface covering (e.g., carpet) if warranted.

9. Document with photos.

VI. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil gas sample.

- When drilling sample collection holes, utilities may be in the area. Always complete utility location, identification and marking before installing sub-slab sample points as required by the ARCADIS Utility Location Policy and Procedure. Be aware that public utility locator organizations frequently do not provide location information within buildings so alternative lines of evidence must be used.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.

- If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative sub-slab soil-gas samples, due to high moisture conditions and/or tight soils, a replacement sub-slab point should be installed, for up to three attempts.

- Field personnel will properly seal the sub-slab point at the slab surface to prevent leaks of atmosphere into the sub-slab point during purging and sampling.

- Quick-setting non-shrink grout and modeling clay or other materials used to seal the hole should only be obtained from an approved ARCADIS source and should not be purchased off the shelf from an unapproved retail source. Data indicate that some modeling clays may contain VOCs that can affect sample results.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches of Hg). Consult your project manager (PM), risk assessor or air sampling expert by phone if the SUMMA® canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from the lab have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in the http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Check the seal around the soil-gas sampling point by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document.

- A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

VII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate sub-slab soil-gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the sub-slab soil-gas point simultaneously.

Trip blank samples will not be used during sub-slab soil-gas sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

X. References

CEPA. 2010. Advisory – Active Soil Investigation. California Environmental Protection Agency. March.

OEPA. 2010. Sample Collection and Evaluation of Vapor Intrusion to Indoor Air. Guidance Document for Remedial Response and Voluntary Action Program. Division of Emergency and Remedial Response. May.

Sub-slab/Soil-Gas Sample Collection Log

		Sample ID:	
Client:		**Boring Equipment:**	
Project:		**Sealant:**	
Location:		**Tubing Information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Subcontractor:**	
`		**Equipment:**	
Sampling Depth:		**Moisture Content of Sampling Zone):**	
Time and Date of Installation:		**Approximate Purge Volume:**	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA® Canister Information:

Size (circle one):	**1 L** **6 L**
Canister ID:	
Flow Controller ID:	
Notes:	

Tracer Test Information (if applicable):

Initial Helium Shroud:	
Final Helium Shroud:	
Tracer Test Passed:	**Yes** **No**
Notes:	

General Observations/Notes:

Approximating One-Well Volume (for purging):

$V_1 + V_2 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of sample tubing; $V_2 = \pi r^2 h$ = open space volume of sample point; V_t = total volume; r = inner radius of sample point, or sample tubing; h = height of sample point or length of tubing.

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SOP 21

Administering Helium Tracer Gas for Leak Checks of Soil-Gas or Sub-slab Sampling Points

RACER

Moraine, Ohio

Rev. #: 2

Rev Date: August 20, 2010

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: ______________________ Date: May 20, 2008
Mitch Wacksman

Reviewed by: ______________________ Date: May 20, 2008
Robert Uppencamp

Approved by: ______________________ Date: November 14, 2008
Christopher Lutes

Modified by: ______________________ Date: Revised: August 20, 2010
Trey Fortner

I. Scope and Application

When collecting subsurface soil-gas samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil-gas point seal. Without the use of a tracer, verification that a soil-gas sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF6), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity where the port or sample tubing intersects the surface with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of high concentrations (>5%) of the tracer. A pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the port during the testing.

There are two basic approaches to testing for the tracer gas:

1. Include the tracer gas in the list of target analytes reported by the laboratory; or

2. Use a portable monitoring device to analyze a sample of soil-gas for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar® bag, etc. They need not be collected in SUMMA® canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the port seals prior to formal sample collection.

During the initial stages of a subsurface soil-gas sampling program, tracer gas samples should be collected at each of the sampling points or in the case of nested points in the shallowest sampling point. If the results of the initial samples indicate that the port seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil-gas points as part of a long-term monitoring program, the port should be tested prior to the first sampling event. Tracer gas testing of subsequent sampling events is not necessary unless conditions have changed at the site.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

III. Equipment List

The equipment required to conduct a helium tracer gas test are presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan)
- Helium
- Regulator for helium tank
- Shroud (plastic bucket, garbage can, etc)
    - The size of the shroud should be sufficient to fit over the soil-gas point manhole. It is worth noting that using a smaller shroud obviously uses less helium as well; this may be important when projects require a number of helium tracer tests.
    - The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two on the side (one for the helium detector probe, and one for the helium line).

  - The shroud ideally encloses the entire sampling train.

- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent)

- Tedlar® bags

- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc). Although the sealing material is not in direct contact with the sample if no leak occurs, sealing materials with high levels of VOC emissions should be avoided, since they could easily contaminate a sample from a point in which a trace leak occurs.

- Field notebook

IV. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of soil-gas point installation. The helium tracer test can be conducted when using temporary or permanent sample point installs and from inside or outside a facility. However, when using the tracer gas within an indoor area you must provide adequate ventilation because helium is an asphyxiant.

1. Attach Teflon® sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., barbed fitting, Swage-Lok® fitting, ball valve, etc.).

2. Place the shroud over the sample point and tubing.

3. Pull the tubing through hole in top of shroud. Seal opening with modeling clay.

4. Place weight on top of shroud to help maintain a good seal with the ground.

5. Insert helium tubing into hole in side of shroud, seal with modeling clay to prevent leaks.

6. Fill shroud with helium. While filling shroud allow atmospheric air to escape either by leaving a crack with the surface or by providing a release value on the side of the shroud.

7. Use the helium detector to test level of helium gas from the bottom of the shroud (where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.

8. Purge the sample point through the sample tubing into a Tedlar® bag using a hand held sampling pump. The sample pump should be operating at a rate of 50 mL/minute (the purge rate should not exceed the sample collection rate). Use a stand-alone flow sensor to monitor purge flow rate during purge (Bios DryCal or equivalent). Test the air in the Tedlar® bag for helium using portable helium detector. If the sample point has been installed properly there should be zero helium in purge air.

9. If > 5% helium is noted in purge air, add more clay or other material to the seal the sample port at the surface and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.

10. Monitor and record helium level in shroud before, during and after tracer test.

11. Monitor and record helium level in purge exhaust.

12. At successful completion of tracer test and sample point purging, the soil-gas sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors!

Care should be taken not to pressurize shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground.

Because minor leakage around the port seal should not materially affect the usability of the soil-gas sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (>5%) of tracer gas are observed in a sample, the port seal should be enhanced to reduce the infiltration of ambient air and the tracer test readministered. If the problem cannot be rectified, a new sample point should be installed.

VI. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

APPENDIX: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.

- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.
- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Special Precautions

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

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SOP 22

Indoor Air and Ambient Air Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 9, 2011

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: ______________ Date: July 7, 2010
Mitch Wacksman

Approved by: ______________ Date: July 7, 2010
Christopher Lutes

Modified by: ______________ Date: Revised, February 9, 2011
Mitch Wacksman

Modified by: ______________ Date: Revised, December 3, 2010
Trey Fortner

I. Scope and Application

This document describes the procedures to collect indoor air and ambient air samples. Samples are collected in an evacuated 6-liter SUMMA®-type canister, (evacuated to <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for placing the sampling device and collecting indoor air or ambient air samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading indoor air or ambient air sample collection activities must have previous indoor air or ambient air sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. The following are examples of hazards that are often encountered in conducting indoor air or ambient air sampling:

- In crawl spaces, hazards often include low head room, limited light, poisonous insects, venomous snakes, insulation, electrical and plumbing lines, and sharp debris.

- In residential buildings and neighborhoods unfamiliar pets can pose a hazard. Even though proper permission for sampling may have been secured, it is still possible to encounter persons suspicious of or hostile to the sampling team. Two sampling personnel are required at all times due to these hazards.

- In occupied industrial buildings be aware of the physical hazards of ongoing industrial processes. Examples include moving forklifts and equipment pits.

IV. Equipment List

The equipment required for indoor air or ambient air sample collection is presented below:

- Appropriate PPE (as required by the Health and Safety Plan);

- 6-liter, stainless steel SUMMA® canisters (order at least one extra, if feasible);

- Flow controllers with in-line particulate filters and vacuum gauges (flow controllers are pre-calibrated by the laboratory to a specified sample duration [e.g., 24-hour]). Confirm with lab that flow controller is equipped with an in-line particulate filter and pressure gauge (order an extra set for each extra SUMMA® canister, if feasible);

- Appropriate-sized open-end wrenches (typically 9/16-inch);

- Chain-of-custody (COC) form;

- Building survey and product inventory form (example attached);

- Portable photoionization detector (PID) (for use identifying potential background sources during building survey described below);

- Sample collection log (attached);

- Field notebook;

- Camera if photography is permitted at sampling locations;

- Portable weather meter capable of collecting barometric pressure, relative humidity, and temperature, if appropriate;

- Box, chair, tripod, or similar to hold canister above the ground surface; and

- Teflon sample tubing may be used to sample abnormal situations (i.e., sumps, where canisters must be hidden, etc.). In these situations ¼-inch Swagelok fittings or other methods may be appropriate to affix tubing to canister. Staff should check this before heading out into field.

V. Procedure

Initial Building Survey for Indoor Air Samples (if applicable to project)

1. Complete the appropriate building survey form and product inventory form (attached) as necessary in advance of sample collection. The product inventory should include ingredients of products as well as quantities. A copy of this completed form will be provided to the property owner to discuss potential background sources.

2. Confirm with building occupants that Instructions for Occupants During Indoor Air Sampling Events has been followed, and use of products that may provide interference with sample results has been discontinued and specified products removed to a non-attached structure at least 48-hours before sampling.

3. Identify on a site plan all underground utilities, piping, or conduits coming into or out of the building to be sampled.

4. Survey the area for the apparent presence of items or materials (i.e. foundation cracks) that may potentially produce or emit constituents of concern and interfere with analytical laboratory analysis of the collected sample. Record relevant information on survey form and document with photographs.

5. Record date, time, location, and other relevant notes on the sampling form.

6. Items or materials that contain constituents of concern and/or exhibit elevated PID readings shall be considered probable sources of VOCs. Request approval of the owner or occupant to have these items removed to a structure not attached to the target structure at least 48 hours prior to sampling, if possible.

7. Set a date and time with the owner or occupant to return for placement of SUMMA® canisters.

Preparation of SUMMA®-Type Canister and Collection of Indoor Air or Ambient Air Sample

1. Record the following information from wherever the sample is being collected (i.e. inside a building for indoor air samples or outside for ambient air samples) on the sampling form (use a hand-held weather meter, contact the local airport or other suitable information source [e.g., weather.gov] to obtain the following information):

   - ambient temperature;
   - barometric pressure;
   - wind speed; and
   - relative humidity.

2. Choose the sample location in accordance with the sampling plan. If a breathing zone sample is required, place the canister on a ladder, tripod, box, or other similar stand to locate the canister orifice 4 to 5 feet above ground or floor surface. If the canister will not be overseen for the entire sampling period, secure the canisters as appropriate (e.g., lock and chain). Canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of “drafts” shall be avoided. Ambient air samples should be placed upwind of the sampling area.

3. Record SUMMA® canister serial number and flow controller number on the sampling log and chain of custody (COC) form. Assign sample identification on canister ID tag, and record on the sample collection log (attached), and COC form.

4. Remove the cap from the SUMMA® canister. Attach the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister with the appropriate-sized wrench. Tighten by hand first, then gently with the wrench. Use caution not to over tighten fittings.

5. Open the SUMMA® canister valve to initiate sample collection. Record the date and local time (24-hour time notation) of valve opening on the sample collection log, and COC form. Collection of duplicate samples will include collecting two samples side by side at the same time.

6. On a floor plan or sketch of the area being sampled, include the following information:

   - Sample location;
   - Locations of heating, ventilation, and air conditioning equipment;
   - Chemical storage areas;
   - Any attached garages or utility areas;
   - Doorways and stairways;
   - Any sumps, drains, or other utility perforations;
   - Separate footings sections or buildings constructions; and
   - The nearest street and the direction of north.

7. All SUMMA®-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches (in) of Hg and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

8. Record the initial vacuum pressure in the SUMMA® canister on the sample log and COC form.

9. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, two SUMMA® canisters will be placed side-by-side and allowed to collect a sample during the exact same period of time.

10. Take a photograph of the SUMMA® canister and surrounding area, if possible.

11. The SUMMA® canister should be checked, if possible, at least once during the 24-hour sampling process and the progress noted on the sampling log.

Termination of Sample Collection

1. Arrive at the SUMMA® canister location at least 1-2 hours prior to the end of the sampling interval (e.g., 24-hour), if possible.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Remove the particulate filter and flow controller from the SUMMA® canister, re-install brass cap on canister fitting, and tighten with wrench.

5. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

6. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with string).

7. Complete COC form and place requisite copies in shipping container. Close shipping container and affix custody seal to container closure. Ship to laboratory via overnight carrier (e.g., Federal Express) for analysis.

VI. Cautions

- Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, keep canisters away from heavy pedestrian traffic areas (e.g., main entranceways, walkways) if possible. If the canisters are not to be overseen for the entire sample duration, precautions should be taken to maintain the security of the sample (e.g., do not place in areas regularly accessed by the public, fasten the sampling device to a secure object using lock and chain, label the canister to indicate it is part of a scientific project, notify local authorities, place the canister in secure housing that does not disrupt the integrity/validity of the sampling event). Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

- If a sub-slab soil-gas sample is collected from a permanent point at the same residence then wait a minimum of 24 hours after the installation of the point before sampling indoor air to minimize cross-contamination from sub-slab soil-gas that may have entered the indoor air during the installation of the point.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 2 to 5–inches Hg) remains in the canister when sample collection is terminated.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 to 27 inches Hg). Consult your project manager (PM), risk assessor or air sampling expert if the SUMMA® canister does not appear to be working properly.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum remaining http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- A Shipping Determination must be completed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

- When collecting ambient air samples it is advisable to contact the local police department to inform them of the sampling and the equipment (i.e. SUMMA®) to be used. This will inhibit any false alarms from concerned citizens.

VII. Waste Management

No specific waste management procedures are required.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager. A building survey form and product inventory form (Attachment A) may also be completed for each building within the facility being sampled during each sampling event as applicable.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Indoor air sample analysis will be according to USEPA Method TO-15. This method uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits. The GC/MS system requires a 1-liter gas sample (which can easily be recovered from a 6-liter canister) to provide a 0.5 ppbv detection limit. The 6-liter canister also provides several additional 1-liter samples in case subsequent re-analyses or dilutions are required. This system also offers the advantage of the GC/MS detector, which confirms the identity of detected compounds by evaluating their mass spectra in either the SCAN or SIM mode.

Trip blank samples will not be used during indoor air or ambient air sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

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Building Survey and Product Inventory Form

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: ____________________________________

Date/Time Prepared: _________________________________

Preparer's Affiliation: ________________________________

Phone No.: ____

Purpose of Investigation: ____

1. OCCUPANT:

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: ____________________________________

Home Phone: _______________________ Office Phone: ________________________

Number of Occupants/Persons at this Location: _________________

Age of Occupants: ______________________

2. OWNER OR LANDLORD: (Check if Same as Occupant ___)

Interviewed: Y / N

Last Name: _________________________ First Name: _________________________

Address: ____

County: _________________________________

Home Phone: ____________________ Office Phone: ____________________

3. BUILDING CHARACTERISTICS:

Type of Building: (circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _________________

If the Property is Residential, Type? (circle appropriate response)

Ranch		2-Family 3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_______________

If Multiple Units, How Many? ___________

If the Property is Commercial, Type?

Business Type(s) _____________________________________

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _________

Other Characteristics:

Number of Floors______ Building Age______

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

4. AIRFLOW:

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow Between Floors

____

____

____

Airflow Near Source

____

____

Outdoor Air Infiltration

____

Infiltration Into Air Ducts

____

____

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS: (circle all that apply)

a.	**Above grade construction:**	wood frame	concrete	stone brick
b.	**Basement type:**	full	crawlspace	slab other ________
c.	**Basement floor:**	concrete	dirt	stone other ________
d.	**Basement floor:**	uncovered	covered	covered with ______________
e.	**Concrete floor:**	unsealed	sealed	sealed with ______________
f.	**Foundation walls:**	poured	block stone	other ____________________
g.	**Foundation walls:**	unsealed	sealed	sealed with ______________
h.	**The basement is:**	wet	damp	dry moldy
i.	**The basement is:**	finished	unfinished	partially finished

j. **Sump present?** Y / N

k. **Water in sump?** Y / N / NA

Basement/lowest level depth below grade: ________(feet)

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Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

Potential Vapor Point Entry	Field Screening Results (ppm)	Comments

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Y / N

6. HEATING, VENTILATING, AND AIR CONDITIONING: (circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Stream radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler
Other __________		

The primary type of fuel used is:

Natural gas	Fuel oil	Kerosene
Electric	Propane	Solar
Wood coal		

Domestic hot water tank fueled by: ______________________________

Boiler/furnace located in: Basement Outdoors Main Floor Other____________

Air conditioning: Central Air Window Units Open Windows None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

____

____

____

7. OCCUPANCY:

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):

Basement ____

1st Floor ____

2nd Floor ____

3rd Floor ____

4th Floor ____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?

Y / N / NA Please specify: ____

d. Has the building ever had a fire? Y / N When? ___________________________

e. Is a kerosene or unvented gas space heater present? Y / N Where? __________________

f. Is there a workshop or hobby/craft area? Y / N Where & Type? ________________

g. Is there smoking in the building? Y / N How frequently? ___________________________

h. Have cleaning products been used recently? Y / N When & Type? _________________

i. Have cosmetic products been used recently? Y / N When & Type? _________________

j. Has painting/staining been done in the last 6 months? Y / N Where & When? ____________

k. **Is there new carpet, drapes or other textiles?** Y / N Where & When? _______________

l. **Have air fresheners been used recently?** Y / N When & Type? ______________________

m. **Is there a kitchen exhaust fan?** Y / N If yes, where ________________________

n. **Is there a bathroom exhaust fan?** Y / N If yes, where vented?_______________________

o. **Is there a clothes dryer?** Y / N If yes, is it vented outside? Y / N

p. **Has there been a pesticide application?** Y / N When & Type?_____________________

q. **Are there odors in the building?** Y / N

If yes, please describe: ____

Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work? Y / N

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N

Date of Installation: _____________________

Is the system active or passive? Active/Passive

Are there any Outside Contaminant Sources? (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify _______________________________

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): __________________

____

Heavy vehicle traffic nearby (or other mobile sources): _________________________________

9. WATER AND SEWAGE:

Water Supply: Public Water Drilled Well Driven Well Dug Well Other: _______

Sewage Disposal: Public Sewer Septic Tank Leach Field Dry Well Other: _______

10. RELOCATION INFORMATION: (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: ________________________________

____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

d. Relocation package provided and explained to residents? Y / N

11. FLOOR PLANS:

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

ARCADIS

First Floor:

12. OUTDOOR PLOT:

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

13. PRODUCT INVENTORY FORM:

Make and Model of field instrument used: ____

List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/ carpet, nail polish/hairspray/cologne).

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y/N

Indoor Air or Ambient Air Sample Collection Log

ARCADIS

		Sample ID:	
Client:		**Outdoor/Indoor:**	
Project:		**Sample Intake Height:**	
Location:		**Tubing Information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Time On/Off:**	
Sample Point Location:		**Subcontractor:**	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA Canister Information:

Size (circle one):	**1 L** **6 L**
Canister ID:	
Flow Controller ID:	
Notes:	

General Observations/Notes:

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 23

Inspection and Vapor Intrusion Mitigation System Design

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: August 9, 2011

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: ______________________ Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: ______________________ Date: May 3, 2011
Rachel Saari

Approved by: ______________________ Date: May 6, 2011
Carolyn Grogan Revised Date: August 9, 2011

I. Scope and Application

This Standard Operating Procedure (SOP) describes the inspection and design procedures to be carried out prior to the installation of active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The inspection procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2003), United States Environmental Protection (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and provide detailed instructions for completing the building inspection and design for active vapor intrusion mitigation systems.

Site-specific requirements and/or field conditions may require modifications to the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All inspection personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific inspection. Drilling with the concrete core drill during communication testing should be done only by personnel with prior experience using such equipment.

IV. Equipment List

The equipment required to complete the inspection and design activities active are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Hammer drill
- Wet/Dry vacuum
- Extra vacuum hose
- Micromanometer – The Fluke 922 Airflow Meter / Micromanometer, or equivalent, will be used for this project. Please see the specification sheet attached to this SOP for details.
- Non-shrink grout
- Tubing
- Swagelok fitting
- Modeling clay
- Flashlight
- Tape measure
- Camera
- Field book or inspection form (attached to the end of this SOP)

V. Procedure

Vapor Mitigation System Inspection (US EPA 625 and ASTM E2121-03)

The following definitions that are commonly used in the vapor mitigation system inspection and design process have been provided for clarification purposes:

- Suction point – The location where the proposed vapor intrusion mitigation system will extract sub-slab, sub-membrane, or crawlspace vapors. For example, a suction point could be a perforated polyethylene flex drain in a crawlspace or a polyvinyl chloride (PVC) pipe that is inserted into a vertical or horizontal suction pit. During communication testing, the vacuum should be applied to a point installed in the location of the suction point and identified as EX-1, EX-2, etc.

- Suction pit – The void installed below slab–on-grade or basement slab foundations.

- Sub-slab sample point – The sample locations used to collect sub-slab pressure field extension readings and background differential pressure readings from below the slab foundation. Permanent sub-slab sample points are installed in accordance with SOP 20, Sub-Slab Soil-Gas Point Installation and Sampling, and can also be used for collection of sub-slab samples. Temporary sub-slab sample points are installed to collect sub-slab pressure field extension readings during communication testing and are installed by drilling a small hole through the foundation. After the communication test is performed the holes are abandoned with non-shrink grout. Typically, the temporary sub-slab sample points are replaced with permanent sub-slab sample points during mitigation system installation. The sub-slab sample points should be labeled as SS-1, SS-2, etc.

Conduct a visual survey and hand sketch for the home to identify the unique characteristics of that home that will need to be considered as part of the system design and construction. Identify the following items, and document any preferences that the homeowner expresses.

a. Identify each separate foundation and its type. Sketch the configuration and note the approximate size of each separate area. Select the proposed suction point location(s) for each foundation and locate on the floor plan.

One suction point should be proposed within each foundation area unless communication between foundations can be demonstrated through completion of a communication test as described below. The following are example suction point locations that are appropriate for a variety of foundation scenarios:

- If a property has a partial basement foundation and a slab–on-grade foundation, two suction points would be proposed (one suction point in the basement foundation and one suction point in the slab-on-grade foundation).

- If a property has one crawlspace foundation that supports the entire structure, one suction point is appropriate.

- If a property has one slab–on-grade foundation and one slab–on-grade addition, two suction points should be proposed (one for each foundation) unless communication testing demonstrates pressure field extension to both areas from one suction point.

b. Include the size and location of crawlspace access doors and the approximate working height within each crawlspace. Note any obstacles that may present a problem for access and if any stored materials will need to be removed. Note whether padding and plywood or other materials will be needed to protect the sheeting and whether the access door will need to be protected from pets or other small animals.

c. For slab-on-grade foundations, sketch the floor plan of the first floor, and identify locations such as closets or utility rooms that may be candidates for system installation. If a second floor is present, identify any locations where the system piping could be installed through both floor levels within closets or other acceptable locations. Identify any cracks or other openings in the slab that are accessible for sealing.

d. Sketch the basement floor plan including the identification of finished and unfinished areas, sumps, floor drains not connected to sewers, cracks, wall to floor joint, open block wall cores, plumbing penetrations, and any other areas that may require sealing. Note the presence of stored items that may need to be relocated to access areas for sealing and system installation. Note any significant degradation in the integrity of the floor and/or walls that would require additional sealing measures beyond the standard caulking procedures.

e. If a sump is present, identify the drains that are connected to the sump and the type of sump pump that is present (pedestal or submersible).

f. Identify gas fired appliances; such has furnaces and water heaters that may need to be checked for backdrafting.

g. On the exterior of the home, identify the number of stories, the type and condition of the roof, and any receptors that may need to be avoided when determining the system discharge location.

h. Identify the location where the piping will exit the structure. Ensure that the pipe can be routed to an appropriate discharge location from this point with minimal or no jogs around windows or other obstructions. The discharge location must be located above the eve of the roof and be at least 10 feet above ground level and at least two feet above or ten feet away from any windows or other openings into the structure or into any adjacent structure. Avoid locating the piping outside of a bedroom, where fan noise could be disturbing to the homeowner.

   Fan placement will either be on the exterior piping or within the attic.

i. Use a micromanometer to measure a background differential pressure at the existing sub-slab sample point at homes with basement and/or slab-on-grade foundations, where an active mitigation system is to be installed, to determine the pre-existing sub-slab pressure that will need to be overcome.

j. Determine if a communication test is to be conducted to assist with predicting system coverage across the entire slab. Crawlspace scenarios do not require a communication test because there is no slab to test below. Communication testing should be performed if:

   1. The suction point will be located greater than 20 feet from the furthest extent of the area it is intended to provide coverage for;

   2. Tight soil conditions are suspected based on site geology or previous sample port/point installation (i.e. clay); and/or

   3. Footers or other barriers (i.e., utilities or sumps) are identified or suspected based on a visual survey that may prohibit communication across the foundation.

An Inspection and Design Flow Chart and a Communication Test Schematic have been attached to this SOP.

k. Communication testing may be conducted during a separate visit and will consist of the following.

- o Drill a one-inch hole through the slab at the proposed suction point location using a hammer drill. Utilize the wet/dry vac for dust control during drilling and use hearing protection.
- o Install temporary sub-slab sample point(s) on opposite side(s) of the slab by drilling small holes (same diameter as the outside diameter of the tubing to be used) through the slab, inserting tubing, and sealing around tubing with modeling clay. Permanent sub-slab sample points will be installed during system construction per the procedures in the Sub-Slab Soil-Gas Point Installation SOP (SOP 20) that is included within this appendix.
- o Connect the suction hose of the wet/dry vacuum to the proposed suction point. Connect extra hose to the discharge of the vacuum and route the discharge to the outdoors.
- o Connect tubing from temporary sub-slab sample point to the positive port of the micromanometer. Record the sub-slab pressure field extension reading, including the positive or negative sign.
- o If a negative pressure of at least 0.004 in w.c. is not obtained at each sub-slab sample point, seal any openings in the slab and repeat the test.
- o If after sealing a negative pressure is not obtained at each sub-slab sample point, identify a second suction point location closer to the area that was not being covered, and repeat the test.
- o After testing is complete, remove the tubing and clay from the temporary sub-slab sample point (s) and fill the suction hole(s) and temporary sub-slab sample point (s) with non-shrink grout.

l. Test combustion appliances to document any pre-existing backdrafting conditions utilizing the following procedure:

1. Turn on the appliance being tested (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding).

2. Check for flue gas spillage near vent hood.

If backdrafting is occurring the owner will be advised of the situation. The necessary repairs must be completed by the owner prior to any vapor control work. Note that high efficiency appliances do not require backdraft testing and can be identified by the presence of PVC vent pipes.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during inspection of vapor intrusion mitigation system. All necessary PPE will be worn during visual inspection and communication testing.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

IX. Data Recording and Management

ARCADIS will keep records of all measurements and notes taken during the inspection, and the information gathered will be used to create a property specific work plan. A detailed inspection form will be completed for each building.

X. Quality Assurance

ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

XI. References

ASTM Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches, October 2008.

Fluke 922

Airflow Meter/ Micromanometer

Technical Data

Today's HVAC technicians need a simple solution for diagnosing ventilation issues. The Fluke 922 makes airflow measurements easy by combining pressure, air flow, and velocity into a single, rugged meter. Compatible with most pitot tubes, the Fluke 922 allows technicians to conveniently enter their duct shape and dimensions for maximum measurement accuracy.

The Fluke 922 Airflow Meter helps you:

- Monitor air pressure across key HVAC components
- Ensure proper air flow balance
- Promote good indoor air quality
- Maintain a comfortable environment

Use the Fluke 922 to:

- Measure pressure drops across filters and coils
- Match ventilation to occupant loads
- Monitor indoor vs. outdoor pressure relationships and manage the building envelope
- Perform duct traversals for accurate airflow readings

Features:

- Powerful meter provides differential and static pressure, air velocity and flow readings
- Rugged design built for field use
- Easy to use without sacrificing performance
- User-defined duct shape and size for maximum airflow accuracy
- Convenient colored hoses help you properly diagnose pressure readings
- Bright, backlit display for clear viewing in all environments
- Min/Max/Average/Hold functions for easy data analysis
- Auto power off saves battery life

FLUKE®

Fluke 922 Airflow Meter Specifications

Feature	Range	Resolution	Accuracy
Operating Specifications			
Air Pressure	± 4000 Pascals ± 16 in H_2O ± 400 mm H_2O ± 40 mbar ± 0.6 PSI	1 Pascal 0.001 in H_2O 0.1 mm H_2O 0.01 mbar 0.0001 PSI	± 1 % + 1 Pascal ± 1 % + 0.01 in H_2O ± 1 % + 0.1 mm H_2O ± 1 % + 0.01 mbar ± 1 % + 0.0001 PSI
Air Velocity	250 to 16,000 fpm 1 to 80 m/s	1 fpm 0.001 m/s	± 2.5 % of reading at 2000 fpm (10.00 m/s)
Air Flow (Volume)	0 to 99,999 cfm 0 to 99,999 m3/hr 0 to 99,999 l/s	1 cfm 1 m3/hr 1 l/s	Accuracy is a function of velocity and duct size
Temperature	0 °C to 50 °C 32 °F to 122 °F	0.1 °C 0.1 °F	± 1 % + 2 °C ± 1 % + 4 °F

General Specifications	
Operating Temperature	0 °C to +50 °C (+32 °F to +122 °F)
Storage Temperature	-40 °C to +60 °C (-40 °F to +140 °F)
Operating Relative Humidity	0 % to 90 %, non-condensing
IP Rating	IP40
Operating Altitude	2000 m
Storage Altitude	12000 m
EMI, RFI, EMC	Meets requirements for EN61326-1
Vibration	MIL-PREF-28800F, Class 3
Max Pressure at Each Port	10 PSI
Data Storage	99 readings
Warranty	2 years
Power	Four AA batteries
Typical Battery Life	375 hours without backlight, 80 hours with backlight

N10140

Fluke 922 comes complete with the following:
Fluke 922 Airflow Meter, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Soft Carrying Case

Fluke 922/Kit comes complete with the following:
Fluke 922 Airflow Meter, 12 in. pitot tube, ToolPak™, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Hard Carrying Case

Ordering Information

Fluke-922	Airflow Meter
Fluke-922/Kit	Airflow Meter with 12 in Pitot Tube
PT12	Pitot Tube, 12 in

Optional accessories

PT12
Pitot Tube, 12 in

TPAK
ToolPak™

Fluke. *Keeping your world up and running.®*

Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

Printed in U.S.A. 8/2007 2791462 D-EN-N Rev C

ARCADIS

Vapor Intrusion Mitigation System
Inspection and Design Form

Property Address: ______ Temperature (Ambient): ______ °F
Tenant's Name: ______ Temperature (House): ______ °F
Owner's Name: ______ Barometric Pressure: ______ "Hg
Owner's Address (If Different from Property Address): Weather Conditions: ______

______

Inspector(s) Name(s): ______
Date and Time: ______
Foundation Type(s): Slab Basement Crawlspace Crawlspace Height: ______
Cracks or Other Areas to be Sealed: Yes No NA
List: ______
Open Block Cores to be Sealed: Yes No NA
List: ______
Sump to be Sealed: Yes No NA Sump Diameter: ______
If Yes, Pedestal Pump, Submersible Pump, or None: ______
Existing Lid to be Reused: Yes No NA
Drain Seals Needed: Yes No
Diameter of Drains: ______ How Many? ______
Backdraft Test Completed on Furnace: Pass Fail NA - High Efficiency
Backdraft Test Completed on Water Heater: Pass Fail NA - Electric or Direct Vent
Reason Backdraft Test not Performed? ______
Failing Backdrafting Condition Reported to Homeowner: Yes No NA
Building Height: 1-Story 2 -Story Other ______
Will Roof be Penetrated: Yes No
Roof Type: Metal Shingle Other ______
Piping to be Installed through or Outside House? ______
Fan will be Located on Exterior or in Attic? ______
Verify Discharge Location will Meet Required Clearance from any Openings into Home or Adjacent Home: Yes No

<u>Suction Point Location and Communication Testing Determination</u>

Are there Multiple Foundation Types? Yes No **(Each foundation type will need to be mitigated)**
If Yes, Indicate Dimensions of Each Foundation: ______
Does the Structure have any Additions? Yes No **(Additions should be considered a separate foundation)**
Is the Suction Point Located Greater than 20 Feet from the Furthest Extent of the Area it is Intended to to Provide Coverage?
Yes No **(If yes, communication testing should be completed)**
Are there Footers or other Barriers that may Impede Communication across Slab? Yes No
(If yes, communication testing should be completed)
Communication Testing to be Completed: Yes No NA
If Communication Testing is not Completed, Reason Why: ______
Background Sub-Slab Pressure: Point ID: ______ Pres: ______ Point ID: ______ Pres: ______

See Back for Communication Test Results

ARCADIS

Vapor Intrusion Mitigation System

Inspection and Design Form

Communication Test Results:

(Apply vacuum to the proposed suction point location(s) during the test.)

Date	Time	Location ID where Vacuum was Applied	Location ID Where Pressure Reading was Collected	Pressure (in w.c.)	Notes

Note: Please label the location IDs on the site sketch consistent with the terminology on the table above.

Is the sub-slab pressure field extension reading more negative than -0.004 in w.c.? Yes No NA **(If No, additional suction points are necessary)**

Note if the Furnace or Air Conditioning is Operating during the Communication Test and Record Background Sub-Slab Pressure Readings. ______________________________

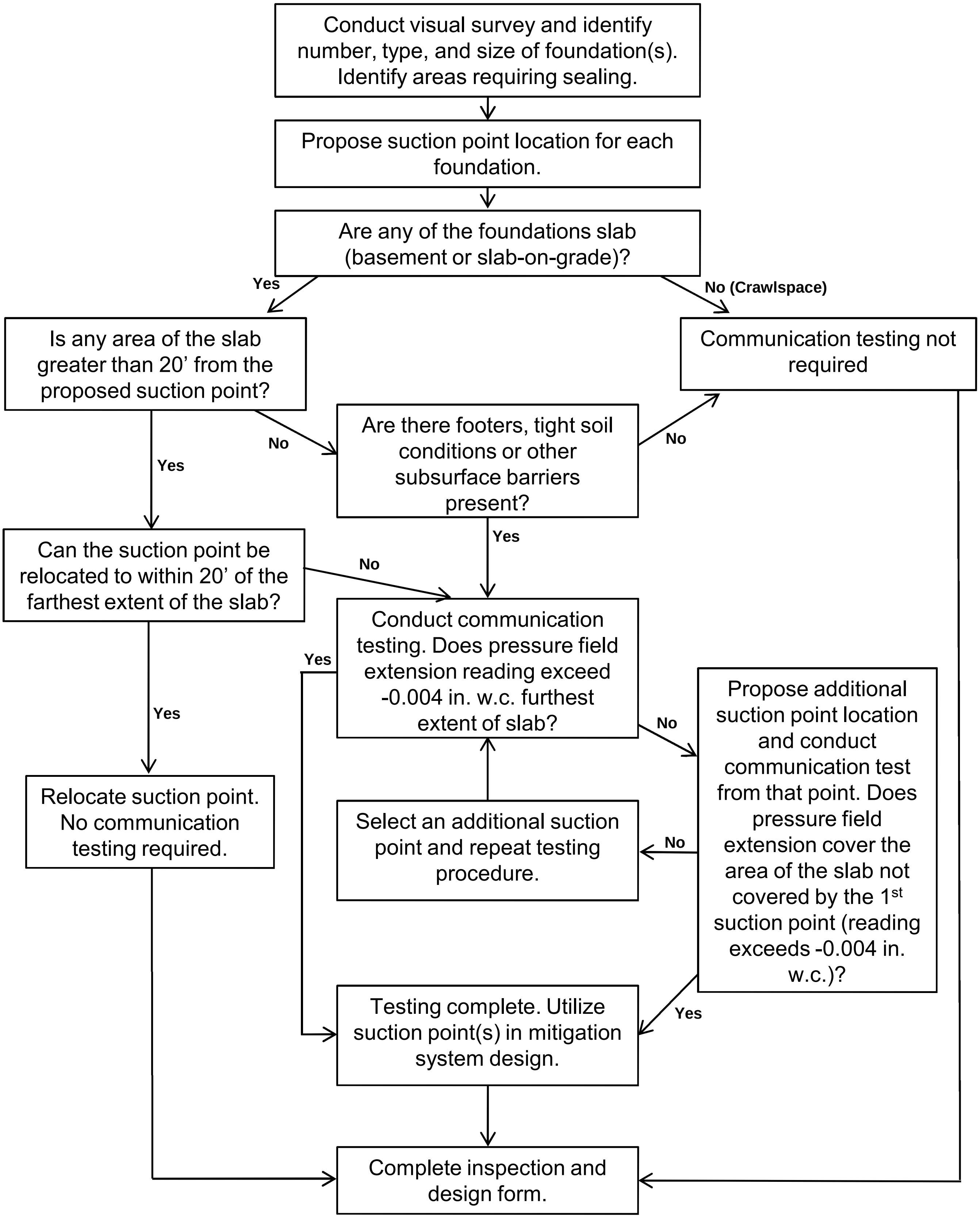
"Hg Inches of Mercury.

In w.c. Inches of Water Column.

A negative pressure reading indicates the presence of a vacuum. A positive reading indicates that there is no vacuum present.

Attach floor plan sketch, including all requirements of the Vapor Mitigation Inspection and Design SOP. Label each foundation type on the sketch.

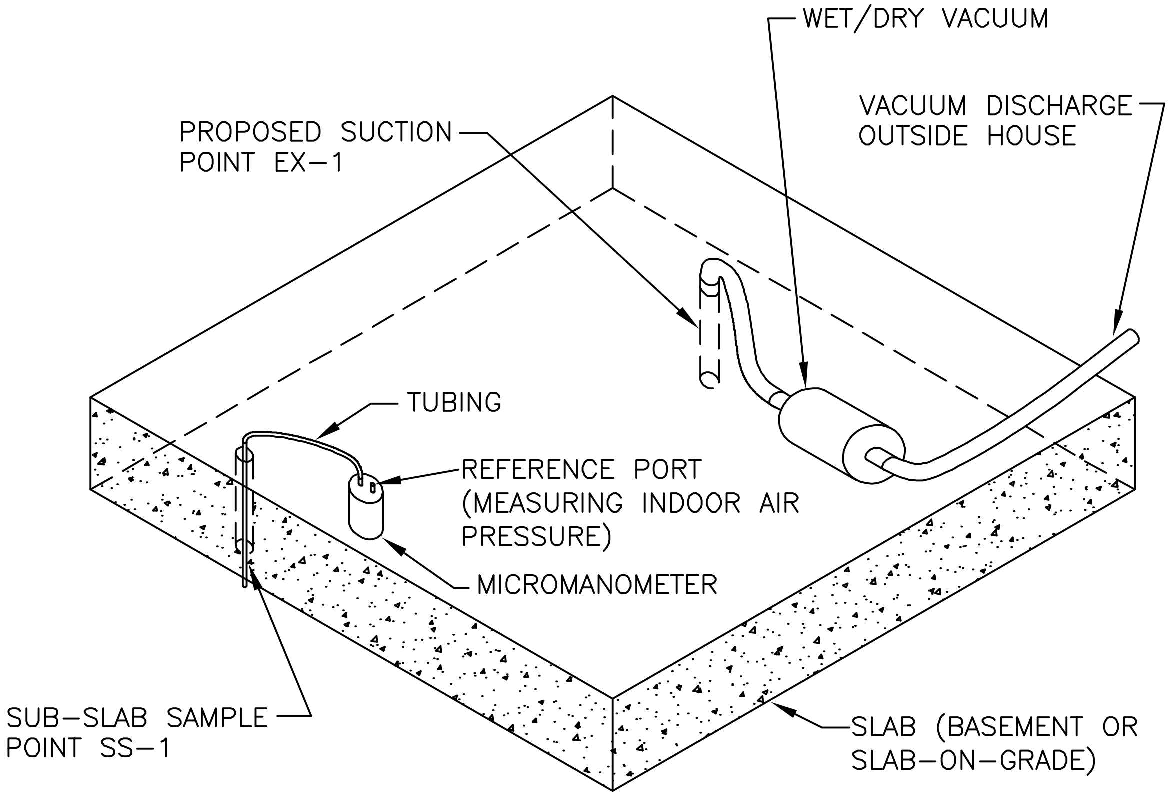
Include photos of exterior of house, all foundation types, exterior discharge location (if applicable), cracks and/or drains to be sealed, and any other relevant photos helpful for understanding the design of the mitigation system.



ARCADIS

SOP 23 INSPECTION AND DESIGN FLOW CHART
RACER
MORAINE, OHIO

Date 8/10/2011	Project Manager N. GILLOTTI	Drawing Name SOP 23 Flow Chart
Drawn By S. BREWER	Lead Design Prof. R. Saari	Checked C. Grogan
Project Number OH000294.2011		Figure Number 1



NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

COMMUNICATION TEST SCHEMATIC SOP 23

ARCADIS

FIGURE
2

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 24

Vapor Intrusion Mitigation System Installation

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 26, 2011

Revised: September 12, 2011

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: May 3, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 26, 2011
Rachel Saari

Modified by: ________________________ Date: September 12, 2011
Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to install active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The active mitigation system should be designed to depressurize the sub-slab, sub-membrane (crawlspace sealed with reinforced, polyethylene sheeting), or inaccessible crawlspace and prevent the entry of soil vapors into the structure. The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and materials and provide detailed instructions for the installation of active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination of the mitigation system installation with the installation contractor and the oversight of the vapor intrusion mitigation system installation activities. ARCADIS personnel leading the mitigation system installation activities will have previous vapor intrusion mitigation system installation oversight experience.

III. Health and Safety Considerations

Installation materials and equipment must be carefully handled to minimize the potential for injury. All installation personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Intrusive methods required for the vapor mitigation system installation (i.e., drilling with a concrete core drilling machine) should be done only by personnel with prior experience of using such equipment. Process pipe installation should be done only by personnel with prior experience and the appropriate training for working at heights. The inline fan shall be wired by a licensed electrician to an independent disconnect switch and to a breaker with sufficient capacity. Installation requirements will be outlined below.

IV. Equipment and Materials List

The equipment and materials required to install active vapor mitigation systems for structures with each of the three different foundation types: basement, crawlspace, and slab-on-grade, or any combinations of these three are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Concrete core drilling machine
- Extension and step ladders
- Drill
- Hand tools
- Lighting
- Vent piping 3 or 4-inch schedule 40 polyvinyl chloride (PVC) pipe, PVC primer, and PVC cement
- Elbows, couplings, pipe supports, and other fittings
- Sealant (silicone and polyurethane caulk)

- 6-mil polyethylene sheeting or 3-mil cross-laminate polyethylene sheeting (crawlspace)
- Untreated 1-inch by 2-inch wood strips, airtight gaskets and mechanical fasteners
- Perforated polyethylene drain tile (crawlspace)
- Backer rod, expandable foam, non-shrink mortar, grouts, etc.
- Roof flashing
- Intumescent fire stops (fire wall penetrations)
- Drain seals and/or water traps
- In-line fan
- Manometer
- Disconnect switch
- Audible alarm

V. Procedure

Active Mitigation System with Basement Foundation Installation (US EPA 625 and ASTM E2121-03)

The following steps will detail installation of an active mitigation system with a basement foundation for the given project.

1. Confirm gathered Information about the Structure: Review floor map to include rooms, crawlspaces, floor drains, cracks, pipe penetrations, plumbing rough-ins, and other openings requiring sealing. Identify any sump pits, drain tile, block walls, or baseboard drainage (see SOP 23 in this Appendix).
2. Backdrafting Check: Prior to system installation, test all combustion appliances and document pre-existing conditions (see SOP 23 in this Appendix).

3. Sealing Potential Vapor Intrusion Routes: Seal all cracks and openings in the basement walls and/or the floor slab to reduce pathways for vapors to enter the structure. Ventilate the structure during caulking activities to prevent the buildup of vapors as necessary. All surfaces to be sealed will be cleaned prior to applying sealant using a wet/dry vacuum. Wire brush may be necessary to loosen dirt or debris prior to vacuuming. Surfaces must be clean, dry, and free of all dirt debris, oil, and grease prior to sealing. Sealing will be conducted utilizing the following methods.

    a. Cracks/Openings: All cracks greater than a 1/2-inch wide will be filled with closed cell foam backer rod prior to applying sealant. Backer rod should be approximately 25 percent larger than the width of the crack. Backer rods should be installed using a roller or flat sided tool to prevent puncture of the rods during installation. Cracks will be sealed with polyurethane caulk by forcing the caulk into the crack and smoothing at or slightly below the floor/wall surface to create a complete seal to each edge of the crack.

    b. Sumps: Sumps will be sealed by installing solid lids with seals around all protrusions through the lid. Lids will be sealed to the floor using a non-permanent caulking, such as silicone, or through the use of an air-tight gasket and mechanical fasteners to allow the opening of the lid for pump maintenance. A view port may also be included in the lid to enable routing inspection of pump performance without repeated removal of the lid.

    c. Drains: Drains installed through sump lids, through crawlspace liners, or through basement floors (not connected to sewer) will be sealed by installing a drain seal consisting of a one way valve which allows water to drain out, but no air to travel up through them or a trapped drain. If a trapped drain is utilized it should be capable of holding a minimum of 6-inches of standing water to minimize the potential for drying out.

    d. Open Block Wall Cores: They will be sealed by filling the top portion of the cores with expanding foam.

    e. Other openings will be evaluated and sealed using polyethylene sheeting, non-shrink grout, mortar, concrete, or expanding foam.

f. Based on specific construction details of each property, other sealing methods may be required.

4. Confirm the Selection and Spacing of Suction Point: Confirm the selection and spacing of the suction points per the design drawing for the structure. The number and spacing of the suction point is based upon diagnostic testing reflective of the properties of soil underneath the building.

5. Confirm Pipe Routing & Fan Placement: These are determined based on design drawing for the structure. Confirm the exterior facade of the property and termination point location with the design drawing.

6. Installation of Suction Pit: Confirm all known utility lines near the proposed suction pit location. Use a portable coring tool to core through the basement slab. Remove approximately1 cubic foot of soil from below the slab. Insert the 3 or 4”-inch PVC vent piping through the slab and seal the opening with polyurethane caulk.

7. Installation of Pipe: Vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction point through the sill plate of the structure and up the exterior of the structure, or routed through the interior of the structure through the attic to the rooftop discharge location per the design drawings. All joints in the PVC piping will be sealed using PVC cement. All of the piping runs will slope back towards the suction point. Extraction piping designed to run along the exterior of the structure will exit the structure at the level of the floor joists. Sealing will be performed around this penetration through the structure. The exterior run of piping will be attached to the side of the structure using clamps. Penetration through the roof and installation of flashing at this penetration will be performed as necessary. For additional pipe installation requirements refer to ASTM E2121 section 7.3.2.

8. Installation of Inline Fan: The Inline fan will be installed within the vent piping on the exterior of the structure when possible. The fan will be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building. The fan will be wired through a local disconnect switch to the structure’s electric panel. A padlock will be installed on the disconnect switch to prevent unintentional shut down of the fan. The associated breaker on the panel will be labeled to indicate it is connected to the fan. For additional fan installation requirements refer to ASTM E2121 section 7.3.3.

9. Installation of Manometer: A manometer will be installed on the vent piping within the basement to confirm on-going system operation within the desired range.

10. If an audible alarm is required, a pressure switch will be installed in the system piping. The switch will be calibrated to alarm if the vacuum within the pipe is outside of the normal operating range.

Active Mitigation System with Slab-On-Grade Foundation Installation

Installation procedures for active mitigation systems with slab-on-grade foundations are the same as the procedures for basement foundations with the following exceptions:

1. The suction pit will be installed through the slab and the vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction pit up through the interior of the structure and through the attic to the rooftop discharge location per the design drawings. The in-line fan will be installed within the vent piping inside the attic of the structure.

Active Mitigation System with Crawlspace/Dirt Floor Foundation Installation

Installation procedures for active mitigation systems with crawlspace foundations are the same as the procedures for basement foundations with the following exceptions:

1. Accessible crawlspaces will be sealed using reinforced, polyethylene sheeting. Adjacent sheets will be overlapped by one foot and sealed with polyurethane caulking. Sheeting will be sealed to the perimeter of the crawlspace and around any protrusions using polyurethane caulking and tape as necessary. Sheeting will be secured to the crawlspace walls using 1-inch by 2-inch (thick by wide) wood strips (non-treated) and concrete anchors. Where moisture is a concern aluminum strips can be used. Exterior crawlspace walls will be sealed as necessary with polyurethane caulking or by extending the sheeting up the exterior walls and securing at the top. Crawlspace access openings may also be covered to prevent pets or other small animals from entering and damaging the sheeting.

2. For accessible crawlspaces, concrete will also be considered to seal dirt floor areas where significant foot traffic (i.e., daily) is expected. If the dirt floor is only periodically used (weekly or less) plastic sheeting protected with foam padding and plywood will be considered.

3. For accessible crawlspaces, the suction point will be installed under the crawlspace sheeting. The suction point will consist of a tee connected to a perforated polyethylene drain tile. The drain tile will create the necessary collection area and prevent the sheeting from being pulled into the vent pipe.

4. Inaccessible crawlspaces will be sealed by identifying and sealing openings from the crawlspace to the first floor with appropriate materials (e.g., polyurethane caulking, expanding foam, and/or polyethylene sheeting). Cracks within the crawlspace foundation walls will be sealed with polyurethane caulking. Larger openings in the foundation will be sealed with expanding foam or covered with sheet metal, sealed with polyurethane caulk, and anchored to the foundation with screws.

5. For inaccessible crawlspaces, a PVC pipe will be inserted into the crawlspace wall and used as the suction point. A screen will be attached to the end of the pipe to prevent small animals from entering the system. Polyurethane caulk will be used to seal the area where the pipe enters the crawlspace.

VII. Safety and Health Hazards (ASTM E2121-03 Section 6.0)

ARCADIS will comply with all OSHA, state and local standards or regulations relating to worker safety and occupational exposure while installing vapor intrusion mitigation systems. In addition to OSHA standards and NIOSH recommendations, the following requirements specifically applicable to the safety and protection of mitigation workers while installing vapor intrusion mitigation system will be met.

- ARCADIS or the mitigation system installation subcontractor will advise the workers of the potential hazards of the materials and supplies used, exposure to contaminants, and the importance of protective measures when working in areas of elevated contaminant concentrations.

- ARCADIS or the mitigation system installation subcontractor will ensure that appropriate safety equipment and applicable material safety data sheets are available at the job site during mitigation activities.

- Work areas shall be ventilated as necessary to reduce worker exposure to contaminants, dust, or other airborne pollutants.

- Vapor mitigation work shall not be conducted in any work area suspected of containing friable asbestos-containing material, or where work would render non-friable asbestos-containing material friable, until a determination has been made by a properly trained or certified person that such work will be undertaken in a manner which complies with applicable asbestos regulations, including those of EPA and OSHA.

- Vapor mitigation work shall not be conducted in any work areas with the potential for exposure to mold or other types of infestations or any other conditions determined to cause an unnecessary safety risk until measures have been taken to eliminate these conditions.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

X. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. The Construction Quality Assurance Manager will complete an As-Built Drawing/Specifications List (attached to this SOP). The construction of the system and details pertaining to the operation of the system will be included in the As-Built Drawing/Specifications List.

2. ARCADIS will provide the property owner with an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) that includes the following :

    a. A description of the mitigation system installed and its basic operating principles.

    b. A description of the proper operating procedures of any mechanical or electrical systems (manometer, in-line fan, etc.) installed, including manufacturer's operation and maintenance instructions.

    c. Contact information to be used if the system failure warning device indicates system degradation or failure or other system maintenance is found to be needed.

d. Contact information for questions about operation of the mitigation system.

XI. Quality Assurance (ASTM E2121-03 Section 7.6)

Upon installation of active mitigation systems in structures with basement or slab-on-grade foundations, a measurement of a negative pressure below the slab of at least 0.004 inches of water column (in. w.c.) will indicate that the active system is successfully depressurizing the sub-slab area. Measurements will be taken on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab.

Upon installation of the mitigation system, an ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c. They will then mark the operating differential pressure on the manometer and will show the owner how to read the manometer installed on the system piping. If at any time the system is not functioning within the range marked on the monitoring device or the owner notices damage to the system, they will be encouraged to call the phone number listed on the system label. ARCADIS will also provide an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) to each owner with contact information for any necessary troubleshooting and repairs. All repairs will be made at no cost to the owner.

A post-installation proficiency sampling will be completed approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air (basement, accessible crawlspace, and first floor) is in compliance with the USEPA Regional Screening Levels at a 1 x 10^{-5} risk level (Action Levels). The sampling will be performed in accordance with the Indoor Air and Ambient Air Sampling SOP (SOP 22) included in this Appendix. Property owners will be provided with a letter to notified them of the sampling results and explain that the results are less than or greater than the Action Levels.

If sampling results are not in compliance with the Action Levels, ARCADIS personnel will evaluate the performance of the active mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). Following completion of the system modifications, an additional post-installation proficiency sampling event will be completed within 30 days. Additional quality assurance measures will be outlined in the Operation and Maintenance SOP.

XII. References

American Society for Testing and Materials (ASTM) Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

United States Environmental Protection Agency (U.S. EPA), Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches. October 2008.

ARCADIS	As-Built Documentation	
	Site Identifier	

Client	RACER	**Installation Location**	
Field Personnel		**Photo Number(s)**	
Site Location	Moraine, Ohio	**Date/Time**	
Project Number	OH000294.2011.00007A	**Contractor**	

Vapor Intrusion Mitigation System Inspection and Design Form Date:

Vapor Intrusion Mitigation System Inspection and Design Form Attached: Yes or No

Design Drawings Attached: Yes or No

Design Drawing Deviations

Additional Notes/Observations

ARCADIS

Vapor Intrusion Mitigation System
Installation Checklist

Address Inspected: ______________________ Property ID #: ______________________

Tenant's Name: ______________________ Owner's Name: ______________________

Owner's Address (If Different from Property): ______________________ Make and Model of Fan: ______________________

Inspector's Name: ______________________ Date Installed: ______________________

Date: ______________________

Time: ______________________

System Pressures	**SS-**	**SS-**	**SS-**	**FAN**
Observed Pressure Field Extension Reading (in w.c.)				
Required Pressure Field Extension Reading (in w.c.)	-0.004	-0.004	-0.004	Between 1 and 4
Difference (in w.c.)				

1.0 Systems Installation and Interior Piping Requirements

	Yes	**No**	**NA**
1.1 Is all system piping Schedule 40 PVC of not less than 3-inch diameter?	______	______	______
1.2 Are all system piping connections permanently sealed? (Exceptions include installation of fan and sump cover)	______	______	______
1.3 Does the system piping avoid attachment to or support from existing pipes, ducts, conduits, or any other kind of equipment?	______	______	______
1.4 Does the system piping avoid blocking windows and doors or access to installed equipment?	______	______	______
1.5 Are supports for system piping installed at least every 6 feet on horizontal runs?	______	______	______
1.6 Are vertical runs secured above or below the points of penetration through floors, ceilings, and roof, and at least every 8 feet?	______	______	______
1.7 Are suction point pipes supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits?	______	______	______

2.0 General Sealing Requirements

	Yes	No	NA
2.1 Is the suction point piping penetration through the slab and/or polyethylene sheeting properly sealed using polyurethane caulk or equivalent?	______	______	______
2.2 Are accessible openings around utility penetrations through the foundation walls and slab, test holes, sub-slab sample points, and any other openings in slabs properly sealed using polyurethane caulk or equivalent?	______	______	______
2.3 Are openings/cracks sealed where the slab meets the foundation wall using polyurethane caulk or equivalent?	______	______	______
2.4 Was backer rod used when sealing cracks greater than ½ inch wide?	______	______	______
2.5 Are drain seals properly installed?	______	______	______
2.6 Is the sump pit installed with an impermeable cover and sealed with O-ring or silicone caulking?	______	______	______
2.7 Are open block cores sealed?	______	______	______
2.8 Is crawlspace sheeting sealed to foundation walls, at overlapping pieces, and at penetrations?	______	______	______
2.9 Is crawlspace sheeting protected from damage?	______	______	______
2.10 Is piping penetration through the siding sealed?	______	______	______
2.11 Is piping centered within roof flashing?	______	______	______

3.0 Electrical Requirements

	Yes	No	NA
3.1 Is the power supply to the fan hard-wired with an electrical disconnect within line of sight and within 4 feet of the fan?	______	______	______
3.2 Is the padlock in place on the disconnect switch?	______	______	______
3.3 Is the electrical service panel labeled to indicate the circuit breaker powering the fan?	______	______	______

4.0 Monitors and Labeling Requirements

	Yes	No	NA
4.1 Does the suction point have a manometer to measure vacuum?	______	______	______
4.2 Is the manometer clearly marked to indicate the initial pressure reading?	______	______	______
4.3 Is a system description label placed on the mitigation system or other prominent location?	______	______	______
4.4 Is the label legible from a distance of at least 3 feet and does it display the following information: Purpose of the system ("Vapor Intrusion Mitigation"), name, address, and phone number of the contact person?	______	______	______
4.5 Was backdraft testing successfully completed after system installation?	______	______	______
4.6 Is the audible alarm operational?	______	______	______

5.0 System Vent Discharge Point Requirements

	Yes	No	NA
5.1 Is the vent pipe discharge vertical and upward, outside the structure, at least 10 feet above ground level, and at least 12 inches above the surface of the roof?	______	______	______
5.2 Is the discharge of the vent pipe 10 feet or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure or any adjacent structure, if the vapor discharge point is not at least 2 feet above the top of such openings?	______	______	______
5.3 Is the outside vent piping fastened to the structure of the building with hangers, strapping, or other supports that will secure it adequately (every 8 feet and within 2 feet of the discharge)?	______	______	______
5.4 Is vent stack piping ID at least as large as the largest used in the manifold piping? Manifold piping to which two or more suction points are connected shall be at least 4 inch ID. (3x4 inch aluminum downspout is an acceptable deviation)	______	______	______
5.5 If metal roof, is piping protected from snow damage?	______	______	______
5.6 Is exterior piping painted to protect from UV damage?	______	______	______

6.0 Fan Installation Requirements

	Yes	No	NA
6.1 Is the fan installed in a configuration that avoids condensation buildup in the fan housing?	______	______	______
6.2 If the fan is mounted on the exterior of buildings, is it rated for outdoor use or installed in a weather proof protective housing?	______	______	______
6.3 Does the system operate without unacceptable noise or vibration?	______	______	______

7.0 Design Drawing and As-Built Drawing Requirements

	Yes	No	NA
7.1 Was the system installed per all requirements of the property-specific work plan?	______	______	______
7.2 Were deviations from the property-specific work plan documented and approved by the U.S. EPA?	______	______	______

8.0 Notes & Comments (List any deviations from the property-specific work plan.)

9.0 Required Corrective Actions

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SOP 25

Vapor Intrusion Mitigation System Operation and Maintenance

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 27, 2011

Revised: September 12, 2011

This SOP was included in the Vapor Intrusion Mitigation Work Plan that was approved by the U.S. EPA on September 14, 2011.

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 27, 2011
Rachel Saari

Modified by: Carolyn Grogan Date: September 12, 2011
Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for operation and maintenance (O&M) of active vapor intrusion mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The O&M procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008); United States Environmental Protection Agency (U.S. EPA) 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993); and U.S. EPA Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010).

The following sections list the necessary equipment and materials and provide O&M instructions for the active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination and oversight of the vapor intrusion mitigation system O&M activities. ARCADIS personnel leading the O&M activities will have previous vapor intrusion mitigation system O&M oversight experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All O&M personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of potential hazards associated with the job site and the specific O&M.

IV. Equipment and Materials List

The equipment required for O&M of active vapor intrusion mitigation systems is presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Micromanometer
- Flashlight
- Inspection form (included at the end of this SOP)
- Camera

V. Procedure

Annual Operation and Maintenance (US EPA Region 5 Vapor Intrusion Handbook, U.S. EPA 625, and ASTM E2121-03)

Inspections will be conducted by ARCADIS to ensure that it is functioning properly. The inspections will cover the following items:

1. The manometer reading will be recorded and checked against the operating value recorded at the completion of the system installation to ensure the system is operating in the design range.

2. The sub-slab pressure field extension readings will be recorded at the sub-slab points that were installed during system construction. The recorded values will be compared to the values recorded at the completion of the system installation.

3. The condition of the fan and disconnect switch lock will be recorded.

4. The condition of the system piping, fittings, and pipe supports will be recorded.

5. The condition of the foundation sealing including crawlspace sheeting will be recorded.

6. Confirmation that the system O&M manual is present will be recorded.

7. Any changes to the building structure or areas in need of additional sealing will be recorded.

If any deficiencies are found, corrective actions will be undertaken as soon as possible and at a minimum within 30 days of discovery.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during the O&M of vapor intrusion mitigation systems. All necessary PPE will be worn during annual inspection.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e. tubing) should be collected by field personnel for proper disposal.

IX. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. ARCADIS will keep records of all mitigation work performed and maintain those records for three years.
2. Health and safety records shall be maintained for a minimum of 20 years.
3. ARCADIS will provide clients with information that includes the following:
    a. Inspection forms
    b. Documentation of corrective actions completed

X. Quality Assurance

After corrective actions have been implemented, manometer readings and sub-slab pressure field extension readings will be recorded as necessary to document the corrective actions have been successfully implemented.

XI. References

ASTM Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

Sub-Slab, Sub-Membrane, and Crawlspace Depressurization Systems - Annual O&M Inspection Form

Property Identification Number: ____________________
Tenant's Name: ____________________
Owner's Name: ____________________
Owners Address (If Different from Property): ____________________

Temperature (Ambient): ____________________ ^{o}F
Temperature (House): ____________________ ^{o}F
Barometric Pressure: ____________________ "Hg
Weather Conditions: ____________________

Inspector Name: ____________________
Date: ____________________
Time: ____________________

System Inspection

Is Fan Operating? Yes No NA
Any Unusual Fan Noises? Yes No
Are Vent Piping and Piping Joints Intact? Yes No
Any Caulking Required Around Piping Penetrations? Yes No
Is System Padlock Intact (System ON/OFF Switch)? Yes No NA
Is O&M Manual Present? Yes No
Any Areas In Need of Additional Sealing? Yes No
List Areas to be Sealed: ____________________
List Any Necessary System Repairs: ____________________

Tenant Observations

Any Change in Fan Noise or Vibration? Yes No
Have you Turned the Fan OFF for Any Period of Time? Yes No NA
Reason? ____________________
Is Differential Pressure in the Manometer Outside of Normal Operating Range? Yes No NA
Is the System Manometer Steady? Yes No NA
Have You or the Owner Made any Changes to the Basement or Other Foundation? Yes No
Is So, What Were the Changes: ____________________

Measurements

Sample Point ID	Post Install Pressure (in w.c.)		Inspection				Post Repair (If Necessary)		
			Date	Time	Pressure (in w.c.)		Date	Time	Pressure (in w.c.)
Manometer									

Comments (Any Repairs Made While Visiting, etc.): ____________________

____

____

Repairs

Additional Sealing Completed: ____________________ Date: __________

System Repairs Completed: ____________________ Date: __________

Note: The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

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SOP 26

Groundwater Sampling Using a Direct-Push Sampling System

RACER

Moraine, Ohio

Rev. #: 3

Rev Date: April 14, 2011

This SOP was included in the Landfill L1 Investigation Work Plan that was approved by the U.S. EPA on November 1, 2011.

Approval Signatures

Prepared by: ______________________ Date: March 11, 2010
Trey Fortner Revised: August 20, 2010

Reviewed by: ______________________ Date: March 11, 2010
Jason Manzo Revised: August 20, 2010

Modified by: ______________________ Date Revised: April 14, 2011
Joseph Rumschlag

I. Scope and Application

This document describes the procedures to collect groundwater at the water table through a retractable stainless steel well screen via a Direct-Push Sampling System. Groundwater samples are collected following low-flow sampling procedures and are analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method 8260.

The following sections list the necessary equipment and provide detailed instructions for the installation of temporary well screen using direct-push technology and the collection of groundwater samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Drilling with a direct-push drilling rig or hollow stem auger rig should be done only by personnel with prior experience using such equipment.

IV. Equipment List

The equipment required to install multiple nested soil-gas ports is presented below:

- Direct Push Drilling Equipment
- Paperwork
- SP16 Screen Point (4 slot and supplied by driller)
- PPE

- Submersible Pump
- Buckets
- Caution Tape and Posts
- Plastic Sheeting
- Pens and Markers
- Sample Bottles
- Cooler
- Tubing (dual size if using a bladder pump)

The direct-push unit utilizes a protected screen sampler that can sample up to approximately 4 feet of water column. To retrieve groundwater samples at the working depth of the unit a submersible pump will be used. Unlike most well points, the unit remains completely sealed by a drive point at the end of the sample tube while it is pushed or driven to the desired sampling depth.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

V. Procedure

At Field Office:

A. Acquire Necessary Equipment

At Sampling Location:

1. Don appropriate PPE.
2. Establish exclusion zone with barricade tape.
3. Place plastic sheeting near work area.
4. After checking to ensure that all parts have been decontaminated, assemble groundwater sampler. All parts must fit tightly. Damage could occur during probing if threaded assemblage is not tight.
5. Drive the well point with the attached probe rods to the water table using manual probe rod driver or hydraulically-powered unit.
6. After the probe rods are driven approximately 2 feet below the water table, expose screen. Lower submersible pump and tubing down through the center of the rods into screened zone. Follow appropriate low-flow methodology for stabilization and transfer water sample to appropriate sample containers.
7. Record all details of sample collection on appropriate field forms.

8. Collect samples into appropriate bottles. Label each bottle with the following information: date, time of sampling, sample ID, analytical method, sampler initials and method of preservation. Print all information accurately and legibly. Complete chain-of-custody forms.
9. Place samples in containers as needed and pack with ice in coolers (when appropriate) as soon as possible.
10. Disassemble the sampler and remove all parts. Decontaminate equipment.
11. Personnel decontamination.

Submit samples to Sample Custodian with chain-of-custody forms and submit all paperwork

VI. Quality Assurance

One duplicate sample must be collected per 20 samples.

A trip blank must accompany each cooler of VOC samples that is shipped during the project.

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SOP 27

Subsurface Soil-Gas Point Installation and Sampling

RACER

Moraine, Ohio

Rev. #: 5

Rev Date: October 11, 2011

This SOP was included in the Landfill L1 Investigation Work Plan that was approved by the U.S. EPA on November 1, 2011.

Approval Signatures

Prepared by: ______________________ Date: Revised, August 20, 2010
Mitch Wacksman

Reviewed by: ______________________ Date: May 20, 2008
Robert Uppencamp

Approved by: ______________________ Date: Revised, October 13, 2009
Christopher Lutes

Modified by: ______________________ Date: Revised, August 20, 2010
Trey Fortner

Modified by: ______________________ Date: Revised, October 11, 2011
Joseph Rumschlag

I. Scope and Application

This document describes the procedures to collect subsurface soil-gas samples using temporary single or nested soil-gas points. Using nested soil-gas points allow for the generation of discrete data as a function of depth and time. Samples from the points are collected in an evacuated PAC250 SUMMA®-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of temporary single or nested soil-gas points (using direct-push technology or a hollow stem auger) and the collection of soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading subsurface soil-gas sample collection activities must have previous subsurface soil-gas sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For subsurface soil-gas point installation, drilling with a direct-push drilling rig or hollow stem auger rig should be done only by personnel with prior experience using such of equipment.

IV. Equipment List

The equipment required to install multiple nested soil-gas points are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Appropriate drill rig to reach necessary sample depth (hollow stem auger, direct-push rig, etc.)
  - Hollow stem auger rig with interconnecting augers. The inner diameter of typical augers ranges from 2.25-inches to 7.75-inches; the auger size should be chosen to reflect the number of nested ports that will be installed inside the boring.
  - Direct-push rig (e.g., Geoprobe®) equipped with interconnecting 4-foot lengths of steel drive rods (1.25-inch diameter to 4-inch diameter depending on the number of ports to be installed).
- Stainless steel sample screens (one per sample depth)
- 0.25 inch outside diameter (OD) x 0.17-inch inside diameter (ID) tubing (Teflon)
- Decontaminated (cleaned) brass valve or needle valve (one per sample depth to match sample tubing)
- Sand
- Granular bentonite (Benseal®, Volclay® Crumbles, or equivalent)
- Down hole measuring device
- Deionized, distilled, or potable water (for hydration of bentonite)
- Aluminum tags for labeling sample depths

- Flush mount well cover
- Photoionization Detector (PID) (with a lamp of 10.6 or 11.7 eV)
- Kneeling pad (as necessary)

The equipment required for soil-gas sample collection from nested soil-gas points are presented below:

- Stainless steel PAC 250 SUMMA® canisters (order at least one extra, if feasible)
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g., 4 minutes, 30 minutes, 8 hours, 24 hours) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible).
- Swage-Lok (or similar) fittings
- Stainless steel Swage-Lok (or similar) “T” fitting (if collecting duplicate [i.e., split] samples)
- Portable vacuum pump capable of producing very low flow rates (e.g., 50 milliliters per minute [mL/min]). Purging flow rate should be selected based on expected soil type (see below)
- Electric flow sensor (Bios DryCal or equivalent) to monitor purge rate
- Tracer gas testing supplies if applicable (refer to SOP 37 for “Administering Tracer Gas”)
- PID
- Landtec GEM™ 500 if field monitoring methane

- Appropriate-sized open-end wrench (typically $^{9}/_{16}$ -inch and ½ -inch)
- Portable weather meter capable of collecting barometric pressure, relative humidity, wind speed, and temperature, if appropriate
- Chain-of-custody (COC) forms
- Sample collection logs
- Field notebook

V. Procedure

Single or Nested Soil-Gas Monitoring Point Installation

The procedure used to install the single or nested soil-gas points will vary based upon the method of boring installation. In most situations a temporary well casing will need to be installed to keep the down hole formation from collapsing during point installation. The following steps will detail installing nested soil-gas points through a temporary well casing.

If the nested soil-gas points will be installed at shallow depths, or the formation is thought to be stable enough to not collapse, a temporary well casing may not be necessary to facilitate the installation of the sample points. Either way, the steps for installing the sample points are nearly identical. These following steps should be discussed with the drilling subcontractor and altered based on the methods chosen for a given project.

1. Advance boring to bottom of deepest sampling interval and install a temporary well casing. Soil-gas points will not be installed in groundwater or the capillary fringe. Moisture conditions and/or other observations (such as depth to water in nearby monitoring wells) should be recorded on the soil-gas collection log, as indicated.

2. Fill in 2 inches of sand pack below the soil-gas point and measure to make sure that the total depth is correct for the stainless steel sample screen to be installed.

3. Cut a length of sample collection tubing slightly longer (e.g., 4 to 5 feet) than the collection depth. Attach a 6-inch stainless steel sample screen to one end of the sample collection tubing and lower the screen and attached tubing through the boring.

4. Assure that the sample screen has reached the bottom of the boring and record this depth.

5. Begin simultaneously filling in the area around the sample screen with clean sand and retracting the temporary well casing. The casing should be lowered back down onto the sand every few inches to compact the sand around the screen. Sand should be introduced to cover the sample screen (6 inches deep) then to extend another six inches above the screen for a total of 14 inches of sand.

6. With the proper sand pack in place begin slowly introducing granular bentonite to the boring while gradually retracting the well casing. A minimum of 12 inches of dry granular bentonite should be added followed by a minimum of 12 inches of hydrated bentonite to 2 inches below the next sample depth. This dry bentonite interval will help ensure water does not reach the sand pack around the sample screen.

7. Properly label the sample tubing with a permanent label to designate the sample number and screen depth with a metal tag.

8. Affix a Swagelok® or equivalent fitting and valve to the end of the tubing. Use caution to not interchange fittings from different manufacturers as this may result in a compromised seal and possible leakage.

9. Fill in 2 inches of sand pack above the hydrated bentonite for below the shallow soil-gas point and measure to make sure that the total depth is correct for the stainless steel sample screen to be installed.

10. Cut a length of sample collection tubing slightly longer (e.g., 4 to 5 feet) than the collection depth. Attach a stainless steel sample screen to one end of the sample collection tubing and lower the screen and attached tubing through the boring.

11. Assure that the sample screen has reached the bottom of the boring and record this depth.

12. Begin simultaneously filling in the area around the sample screen with clean sand and retracting the temporary well casing. The casing should be lowered back down onto the sand every few inches to compact the sand around the screen. Sand should be introduced to cover the sample screen then to extend another six inches above the screen .

13. Repeat steps 6 through 8.

14. When installing the shallowest (last) sample point, bentonite should be emplaced all the way to the ground surface or bottom of the vault (if applicable) for a minimum of 5 feet of bentonite to ensure no short circuiting with the ambient air.

15. With all temporary single or nested points installed and labeled, a well cover may be installed.

    a. For permanent installations, the well cover should be rated for whatever type of traffic it may encounter in the future. For interior installations a brass clean-out cover available from a plumbing supply store may provide adequate protection. For exterior installations in high traffic areas a heavy duty groundwater well cover may be appropriate.

    b. For a temporary installation, a well cover is generally not necessary as the tubing will be removed within several days.

16. All soil-gas points should be allowed to sit and equilibrate for a minimum of 48 hours before proceeding to soil-gas sample collection (CEPA, 2010).

Soil-Gas Sample Collection

<u>The following steps should be used to collect a soil-gas sample from each of the single or nested points installed using the above procedure.</u>

1. Record the following information in the field notebook, if appropriate (contact the local airport or other suitable information source [e.g., site-specific measurements, weatherunderground.com] to obtain the information):

a. wind speed and direction (if capable with in-field measuring device);

b. ambient temperature;

c. barometric pressure; and

d. relative humidity.

2. Connect a properly calibrated portable vacuum pump to the sample tubing.

3. Purge 3 volumes of air from the soil-gas point screen and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing, sample screen, sand pack and dry bentonite seal using the calculation:

$$V_1 + V_2 + V_3 = V_t$$

where:
$V_1 = \pi r^2 h$ = open space volume of soil-gas screen
$V_2 = \pi r^2 h$ = open space volume of sample tubing
$V_3 = \pi r^2 h\rho$ = estimated volume of sand pack and dry bentonite open pore space
V_t = total volume
r = inner radius of soil-gas screen, borehole, or sample tubing
h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal
ρ = porosity of sand pack and dry bentonite (40%)

4. All SUMMA®-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

5. If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative soil-gas samples, due to high moisture conditions

and/or tight soils, a replacement probe should be installed approximately 5 feet from the original location, for up to 3 attempts.

6. A "shut in" test will be preformed prior to sampling each soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA® canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA® canister will be placed on the end of the sample train, effectively creating a closed system. The SUMMA® canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively "shut-in" to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.

7. A tracer gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around the all soil-gas points by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP "Administering Tracer Gas," for procedures on tracer gas use.] If unacceptable leaks are detected (≥ 5% of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement probe should be installed and sampled approximately 5 feet from the original location.

8. Remove the brass plug from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister. Record in the field notebook and COC form the flow controller number with the appropriate SUMMA® canister number.

9. Connect the Teflon® sample collection tubing to the flow controller and the SUMMA® canister valve.

10. Open the SUMMA® canister valves. Record in the field notebook and/or sample log (attached) the time sampling began, canister vacuum (as noted on the vacuum gauge), sampling flow rate specified from the laboratory, canister number, and flow controller number.

11. Take photographs of the SUMMA® canister and surrounding area; as appropriate.

12. Steps 2-10 should be repeated for each of the nested soil-gas points; samples can be collected concurrently.

Termination of Sample Collection

1. Due to the short duration of the soil-gas samples, field staff should stay at the SUMMA® canister location through the entire sampling interval.

2. Record the final canister vacuum. Stop collecting the sample by closing the SUMMA® canister valves. The canister should have a minimum amount of vacuum (approximately 5-inches of Hg or slightly greater).

3. Record the date and time of valve closing in the field notebook, sample collection log, and COC form.

4. Close the valve on the nested soil-gas sample tubing.

5. Once all the nested samples have been collected, be sure the well cover (if applicable) is properly re-installed and secured.

6. Remove the particulate filters and flow controllers from the SUMMA® canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.

7. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canisters should not be preserved with ice or refrigeration during shipment.

8. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

9. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.

10. In accordance with standard operating procedures, equipment decontamination procedures, chain-of-custody procedures, and equipment calibration and maintenance procedures should be strictly followed.

VI. Soil-Gas Monitoring Point Abandonment

If the single or nested soil-gas points were installed in a temporary manner, and the soil-gas samples have been collected, the soil-gas monitoring points will be abandoned by pulling up the sample tubing. Since the boring is filled with bentonite and sand, no additional abandonment steps are necessary. Ensure that the boring location and surrounding area are returned to as close to their original appearance as possible.

VII. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a single or nested soil-gas sample.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.

- Care should be taken to ensure that nested ports are installed at the target sample depths. Sampling personnel should work closely with the driller to ensure this is implemented.

- When introducing granular bentonite to the boring, the material should be introduced slowly and hydrated properly. Consult the bentonite manufacturer's instructions on the bag to determine the proper amount of to be used. When hydrated properly bentonite forms a thick clay mass that remains moist. The hydration step is crucial in the installation process and if not done properly the integrity of the bentonite seal can be compromised.

- Installing a layer of dry bentonite directly above the sand pack will help ensure water does not reach the sand pack around the sample screen.

- It is important to record the canister pressure, start and stop times and ID on a proper field sampling form. Often SUMMA® canisters are collected with a 24 hour averaging period. You should observe and record the time/pressure at the start, and then again one or two hours after starting the sample collection. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches). Consult your Project Manager (PM), risk assessor or air sampling expert by phone if the SUMMA® canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. In some cases the gauges sent from labs may have large offset errors, or they malfunction (stick). For the most precise pressure readings consider using a separate, more sensitive, device to do checks at the beginning and end of the sampling period. If this is used, it must be tested beforehand to confirm that it does not introduce contaminants to the can during pressure checks.

- If possible, have equipment shipped a day or two before the sampling date so that all materials can be checked.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Soil-gas sampling should not proceed within 5 days following a significant rain event (1/2-inch of rainfall or more).

A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

IX. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

X. Quality Assurance

Duplicate samples will be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 20 air samples (5%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate soil gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the soil-gas probe simultaneously.

Trip blank samples will not be used during soil gas sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous, therefore there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

XI. References

ASTM – “Standard Guide for Soil Gas Monitoring in the Vadose Zone”, D5314-92.

Hayes, H. C., D.J. Benton and N. Khan “Impact of Sampling media on Soil Gas Measurements” Presented with short paper at AWMA Vapor Intrusion Conference January 2006, Philadelphia PA.

CEPA, 2010: California Environmental Protection Agency. 2010. “Advisory – Active Soil Investigation”. March.

http://www.dtsc.ca.gov/SiteCleanup/upload/SAG_Review_Drft.pdf

ITRC “Vapor Intrusion Pathway: A Practical Guide”, January 2007, Appendix F: “regulators Checklist for Reviewing Soil Gas Data”.

New York State Department of Health (NYSDOH). 2005. DRAFT “Guidance for Evaluating Soil Vapor Intrusion in the State of New York” February 23, 2005.

Nicholson, P, D. Bertrand and T. McAlary. “Soil Gas Sampling in Low-Permeability Materials” Presented at AWMA Specialty Conference on Vapor Intrusion, Providence RI, Sept. 2000.

Sub-slab/Soil-Gas Sample Collection Log

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		Sample ID:	
Client:		**Boring Equipment:**	
Project:		**Sealant:**	
Location:		**Tubing Information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Subcontractor:**	
`		**Equipment:**	
Sampling Depth:		**Moisture Content of Sampling Zone):**	
Time and Date of Installation:		**Approximate Purge Volume:**	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA® Canister Information:

Size (circle one):	**250 mL 1L**
Canister ID:	
Flow Controller ID:	
Notes:	

Tracer Test Information (if applicable):

Initial Helium Shroud:	
Final Helium Shroud:	
Tracer Test Passed:	**Yes No**
Notes:	

General Observations/Notes:

Approximating One-Well Volume (for purging):

$V_1 + V_2 + V_3 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of soil-gas screen; $V_2 = \pi r^2 h$ = open space volume of sample tubing; $V_3 = \pi r^2 h \rho$ = estimated open pore space for sand pack and dry bentonite seal; V_t = total volume; r = inner radius of soil-gas screen, borehole, or sample tubing; h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal; ρ = porosity of sand pack and dry bentonite seal (40%).

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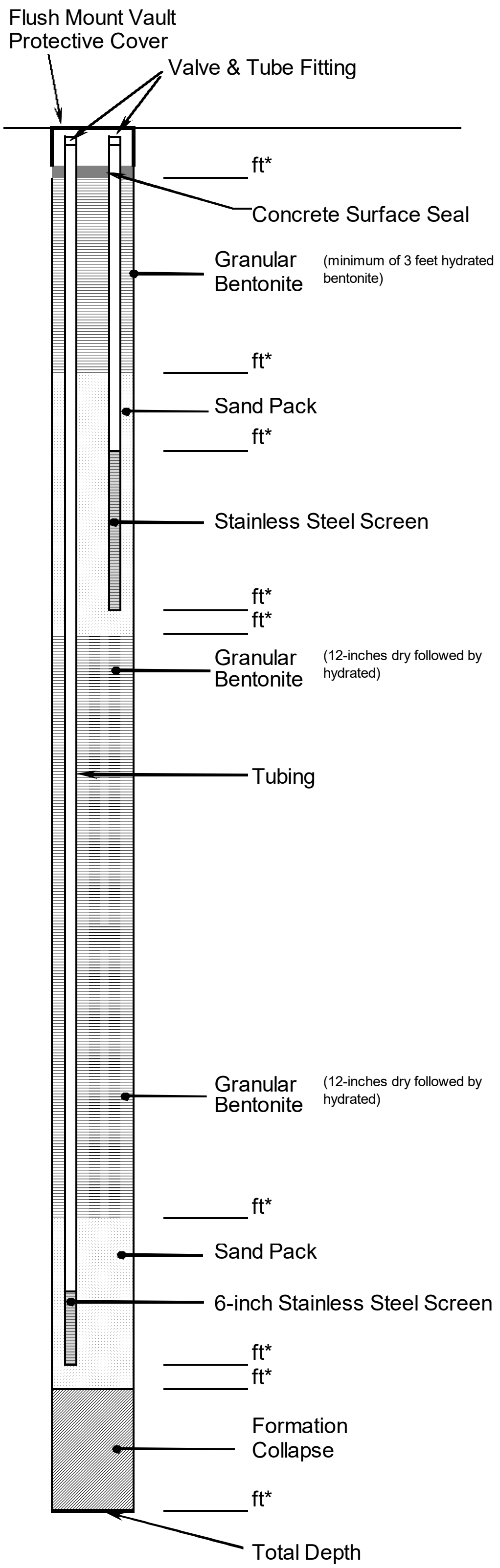
SOIL-GAS POINT CONSTRUCTION DIAGRAM



* Depth in Feet Below Land Surface

Project: ______________________ Point: ________

City: ______________________

County: ______________________ State: ________

Survey Coordinates:

Northing: ______________________

Easting: ______________________

Land-Surface Elevation (surveyed): ________ feet (above mean sea level)

Historic Maximum Groundwater Elevation: ________ feet (above mean sea level)

Groundwater Encountered During Drilling: ________ feet bls

Installation Dates: ______________________

Weather Conditions at Installation: ______________________

Drilling Contractor: ______________________

Driller: ______________________

Drilling Method: ______________________

Screen Construction:
Type: Stainless Steel - 6 inches
Diameter: 0.4375-inch OD, 0.3125-inch ID
Type: Stainless steel - 60 inches
Diameter: 0.5-inch ID

Tubing Construction:
Type: Teflon®
Diameter: 0.25-inch OD, 0.17-inch ID

Volume Calculation (mL):

	Shallow	Deep
V_1		
V_2		
V_3		
V_t		

Remarks: ______________________________________

Prepared by: ______________________

$V_1+V_2+V_3=V_t$ where: $V_1=\pi r^2 h$ = open space volume of soil-gas screen; $V_2=\pi r^2 h$ = open space volume of sample tubing; $V_3=\pi r^2 h\rho$ = estimated open pore space for sand pack and dry bentonite seal; V_t = total volume; r = inner radius of soil-gas screen, borehole, or sample tubing; h = height of soil-gas screen or height (length) of tubing or height of sand pack and dry bentonite seal; ρ = porosity of sand pack and dry bentonite seal (40%).

OD - outer diameter
ID - inner diameter
bls - below land surface

12-inches = 1 foot
1 cubic inch = 16.39 mL
π = 3.1416

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SOP 28

Air Monitoring using an ORION Plus MultiGas Portable Gas Meter

RACER

Moraine, Ohio

Rev. #: 1

Rev Date: April 20, 2011

This SOP was included in the Landfill L1 Investigation Work Plan that was approved by the U.S. EPA on November 1, 2011.

Approval Signatures

Prepared by: ______________________ Date: 10/23/2007
Kevin Patton

Reviewed by: ______________________ Date: 4/20/2011
Joseph Rumschlag

Approved by: ______________________ Date: 4/20/2011
Jason Manzo

I. Scope and Application

This standard operating procedure describes a methodology for correctly calibrating and using the ORION Plus MultiGas portable gas monitor, manufactured by MSA, Inc. This instrument monitors oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and methane (CH_4). These gases are typically present in landfills and need to be monitored when performing subsurface exploration or groundwater monitoring (if necessary) at landfills as their presence could produce oxygen deficient or explosive atmospheres. The ORION Plus MultiGas portable gas monitor is intrinsically safe for use at landfills.

II. Personnel Qualifications

All field personnel are required to take the 40-hour OSHA health and safety training course and associated 8-hour refresher courses prior to engaging in any field activities.

III. Equipment List

- ORION Plus MultiGas portable gas meter
- Daily field log or logbook
- ORION Plus MultiGas portable gas meter owner's manuals (attached)
- Calibration gases
- Water sample trap

V. Health and Safety Considerations and Cautions

Performing subsurface investigations or groundwater monitoring at landfills involves dangers related to explosive or oxygen-deficient atmospheres. Air monitoring must be performed using properly functioning equipment.

VI. Procedure

NOTE: The following is a generalized description summary of the procedures to be followed when using the ORION Plus MultiGas portable gas meter. Detailed procedures are presented in the attached Operation Manuals and should be referenced.

1. Ensure that the portable gas meter has sufficient battery power.

2. Turn the unit on and allow pump to start.

3. Once gas readings are displayed, verify the pump is operating correctly by plugging the free end of the sampling line or probe, ensure that the audible

alarm sounds indicating the pump is blocked.

4. Once you have verified the pump is working, press clear to return to readings and reactivate the pump.

5. Connect the water sample trap and hose to the unit.

6. Turn the “pump” button to “on” and the unit should begin logging data.

7. When monitoring ambient air for field health and safety purposes, continuously check the unit to ensure that the power is on and the values are in the accepted range.

8. Periodically record the data from the monitor in the field log book and/or daily log.

9. If collecting a reading from a landfill well, carefully lift the cap slightly and extend the tube in the well. If performing ambient air monitoring for health and safety purposes, the unit should be held in the breathing zone.

Record the maximum value in the field log book and/or daily log. This information should also be recorded on the sampling log for the boring/well.

VIII. Data Recording and Management

Any data related to the calibration and use of the unit should be recorded in a field log book and/or daily log. If the readings are related to the sampling of a well they should be recorded on the sampling log for the given well.

IX. Quality Assurance

If field forms and lab data are input or tabulated electronically after the field program, they should be compared to the original field forms to ensure accuracy.

X. References

MSA ORION Plus MultiGas Detector, Operating Manual, MSA North America; Part number 10078576 (attached).

Orion® *plus* MultiGas Detector

The Safety Company

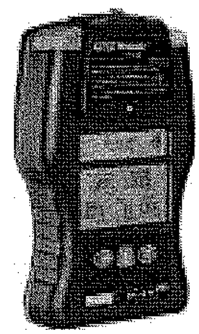
Operating Manual

Detector multigas Orion® *plus*

Manual de Operación

Détecteur multi-gaz Orion® *plus*

Mode d'emploi



In North America, to contact your nearest stocking location, dial toll-free 1-800-MSA-2222
To contact MSA International, dial 1-412-967-3354 or 1-800-MSA-7777

This manual is available on the internet at www.msanet.com

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Pour contacter MSA International, composez le 1-412-967-3354 ou 1-800-MSA-7777

Ce manuel est disponible sur Internet à www.msanet.com.

Manufactured by/Fabricado por/Fabriqué par

MSA NORTH AMERICA

P.O. Box 427, Pittsburgh, Pennsylvania 15230

(L) Rev 1 IMZ001-029-N 10078576

Orion® *plus* MultiGas Detector

The Safety Company

Operating Manual

In North America, to contact your nearest stocking location, dial toll-free 1-800-MSA-2222
To contact MSA International, dial 1-412-967-3354 or 1-800-MSA-7777

This manual is available on the internet at www.msanet.com

Manufactured by

MSA NORTH AMERICA

P.O. Box 427, Pittsburgh, Pennsylvania 15230

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⚠ WARNING

THIS MANUAL MUST BE CAREFULLY READ BY ALL INDIVIDUALS WHO HAVE OR WILL HAVE THE RESPONSIBILITY FOR USING OR SERVICING THE PRODUCT. Like any piece of complex equipment, this instrument will perform as designed only if it is used and serviced in accordance with the manufacturer's instructions. OTHERWISE, IT COULD FAIL TO PERFORM AS DESIGNED AND PERSONS WHO RELY ON THIS PRODUCT FOR THEIR SAFETY COULD SUSTAIN SEVERE PERSONAL INJURY OR DEATH.

The warranties made by Mine Safety Appliances Company with respect to the product are voided if the product is not used and serviced in accordance with the instructions in this manual. Please protect yourself and others by following them. We encourage our customers to write or call regarding this equipment prior to use or for any additional information relative to use or repairs.

Table of Contents

Chapter 4, Setting up the Multigas Detector 4-1

Chapter 5,
Instrument Setup and Calibration 5-1

Chapter 1, Instrument Safety and Certifications

The Orion plus Multigas Detector is for use by trained and qualified personnel. It is designed to be used in air when performing a hazard assessment.

The Orion plus Multigas Detector can be equipped to detect:

- Combustible gases and certain combustible vapors
- Oxygen-deficient or oxygen-rich atmospheres
- Specific toxic gases for which a sensor is installed.

⚠ WARNING

Safety Limitations and Precautions

Carefully review the following warnings, safety limitations and precautions before placing this instrument in service:

- The Orion plus Multigas Detector is designed to detect (in air only) combustible gases and vapors and specified toxic gases for which a sensor is installed.
- Perform the following checks before each day's use to verify proper instrument operation:
  - Gas response check (see Calibration section)
  - Calibrate if the readings are not within the specified limits.
  - Check pump for proper operation (see "Verifying Pump Operation" section). Have pump serviced if necessary.
- Check calibration more frequently if the unit is subjected to physical shock or high levels of contaminants. Also, check calibration more frequently if the tested atmosphere contains the following materials, which may desensitize the combustible gas sensor and reduce its readings:
  - Organic silicones
  - Silicates
  - Lead-containing compounds
  - Hydrogen sulfide exposures over 200 ppm or exposures over 50 ppm for one minute.
- A combustible gas reading of "100" indicates the atmosphere is

above 100% LEL and an explosion hazard exists. In such cases, the instrument LockAlarm feature activates. Move away from contaminated area immediately.

- Do not use the Orion plus Multigas Detector to detect combustible dusts or mists.
- Do not use the Orion plus Multigas Detector to test for combustible or toxic gases in the following atmospheres as this may result in erroneous readings:
  - Oxygen-deficient or oxygen-rich atmospheres
  - Reducing atmospheres
  - Furnace stacks
  - Inert environments
  - Atmospheres containing combustible airborne mists or dusts.
- Do not use the Orion plus Multigas Detector to test for combustible gases in atmospheres containing vapors from liquids with a high flash point (above 100°F) as this may result in erroneously low readings.
- Do not block pump inlet as this may cause inaccurate readings. Do not press on the face of the sensors, as this may damage them and cause erroneous readings. Do not use compressed air to clean the sensor holes, as the pressure may damage the sensors.
- Allow sufficient time for unit to display an accurate reading. Response times vary based on the type of sensor being used (see Chapter 7, "Performance Specifications"). Additionally, when using a sampling pump, allow a minimum of 0.7 seconds per foot of sample line to allow the sample to be drawn through to the sensors.
- Keep the probe tip above liquid surfaces; otherwise, liquid may enter the system and block the sample flow, causing inaccurate readings and/or internal damage.
- All instrument readings and information must be interpreted by someone trained and qualified in interpreting instrument readings in relation to the specific environment, industrial practice and exposure limitations.
- Replace alkaline cells or recharge NiMH battery-pack in non-hazardous areas only. Use only battery chargers listed in this manual; other chargers may damage the battery pack and the unit. Dispose of batteries in accordance with local health and safety regulations.

- Do not alter this instrument or make any repairs beyond those specified in this manual. Only MSA-authorized personnel may repair this unit; otherwise, damage may result.

Certifications

Tests completed by MSA verify that the Orion plus Multigas Detector meets applicable industry and government standards as of the date of manufacture.

Electronic Interference

- This instrument generates, uses, and can radiate radio frequency energy. Operation of this instrument may cause interference, in which case, the user may be required to correct.
- This device is test equipment and is not subject to FCC technical regulations. However, it has been tested and found to comply with the limits for a Class A digital device specified in Part 15 of the FCC regulations.
- This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the CRTC.
- There is no guarantee that interference will not occur. If this instrument is determined to cause interference to radio or television reception, try the following corrective measures:
    - Reorient or relocate the receiving antenna
    - Increase separation between the instrument and the radio/TV receiver
    - Consult an experienced radio/TV technician for help.

Chapter 2, Quick Start

It is your responsibility to know how to use the Orion plus Multigas Detector. When used properly, this unit will alert you to the presence of:

- combustible gases and vapors
- atmospheres that are rich or deficient in oxygen
- specific toxic gases if equipped with the appropriate sensor.

These conditions are displayed clearly and simultaneously on the face of the instrument. See Chapter 3, FIGURE 3-3 for an explanation of the flags, numbers and button operation of the Orion plus Multigas Detector.

Turning ON the Orion plus Multigas Detector

1. Push the ON-OFF button to turn ON the Orion plus Multigas Detector with an installed battery pack:
    - The instrument then performs a Self-test where the:
        - instrument details are displayed
        - audible alarm sounds
        - alarm lights illuminate
        - display backlight illuminates.

Once the Self-test is complete, the instrument:

- requests that a Fresh Air Setup be performed
- is ready for use after this Fresh Air Setup procedure is performed or rejected.

Moving Through the Orion plus Multigas Detector Pages

To access instrument features and informational pages:

- Push the PAGE button (See Chapter 3, FIGURE 3-3).

The Pages appear in the following order:

- **Minimum**
  Shows minimum value recorded since last instrument turn-ON for the oxygen sensor only.

- **Maximum**
  Shows peak value recorded since last instrument turn-ON.
- **TWA**
  Shows Time Weighted Average for installed toxic gas sensors.
- **STEL**
  Shows Short Term Exposure Limit for installed toxic gas sensors.

To return the instrument to the Measure page:

- Push the RESET button.
  - The instrument automatically returns to the Measure page after a 20-second delay on any page.

Turning OFF the Orion plus Multigas Detector

To turn OFF the Orion plus Multigas Detector:

- Push and hold the ON-OFF button for five seconds.
  - Hourglass displays to indicate instrument turn-OFF.

Chapter 3,
Using the Orion plus Multigas Detector

Turning ON the Orion plus Multigas Detector

Installing the Battery Pack (FIGURE 3-1)

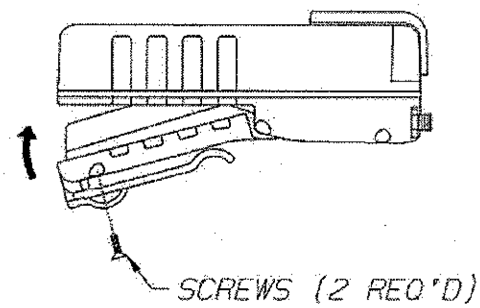

Figure 3-1. Battery Pack Installation

1. Slide the battery pack toward the top of the instrument.
2. Swing the battery pack up and into the body of the instrument.
3. Secure the battery pack by installing the two screws in the bottom two corners of the battery pack and instrument.

   NOTE: The screws must be snug to ensure that the battery pack properly seals to the instrument. Do not over-tighten.

4. Once the battery pack is installed, the Orion plus Multigas Detector turns ON.

⚠ WARNING

A calibration check must be performed after switching battery packs to assure accuracy of readings.

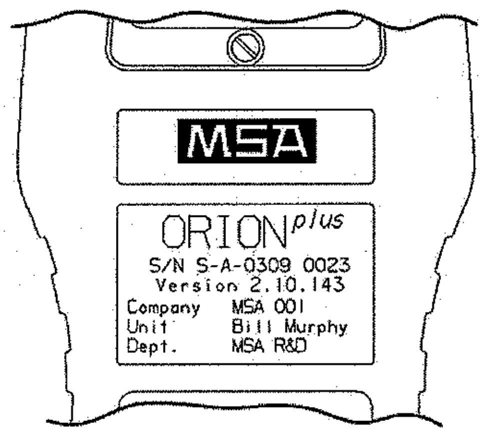

Figure 3-2 Startup Screen

The instrument now performs the following Self-test where the:

- Instrument details are displayed
- Audible alarm sounds
- Alarm lights illuminate
- Display backlight illuminates
- Internal instrument diagnostic occurs
  (any detected internal errors appear on the display) and all pre-set alarms are displayed.

When the Self-test ends:

- The instrument offers the FAS option to zero the instrument
  - If the FAS is declined or no buttons are pressed, the instrument enters the Measure mode
- Gas concentrations appear on the display.

Fresh Air Setup Option

(for automatic zero adjustment of the Orion plus Multigas Detector sensors)

NOTE: The Fresh Air Setup (FAS) has limits. If a hazardous level of gas is present, the Orion plus Multigas Detector ignores the

FAS command and goes into alarm.

⚠ WARNING

Do not activate the Fresh Air Setup unless you are certain you are in fresh, uncontaminated air; otherwise, inaccurate readings can occur which can falsely indicate that a hazardous atmosphere is safe. If you have any doubts as to the quality of the surrounding air, do not use the Fresh Air Setup feature. Do not use the Fresh Air Setup as a substitute for daily calibration checks. The calibration check is required to verify span accuracy. Failure to follow this warning can result in serious personal injury or death.

Persons responsible for the use of the Orion plus Multigas Detector must determine whether or not the Fresh Air Setup option should be used. The user's abilities, training and normal work practices must be considered when making this decision.

1. Turn ON the Orion plus Multigas Detector.
   - Once the instrument self check is complete, the instrument offers a Fresh Air Setup option.
2. To perform a Fresh Air Setup, push the display indication YES (RESET) button.
3. To immediately skip the FAS, push the NO (PAGE) button.
   - If no buttons are pushed, the Orion plus Multigas Detector enters the Measuring mode.

Understanding the Display (see FIGURE 3-3)

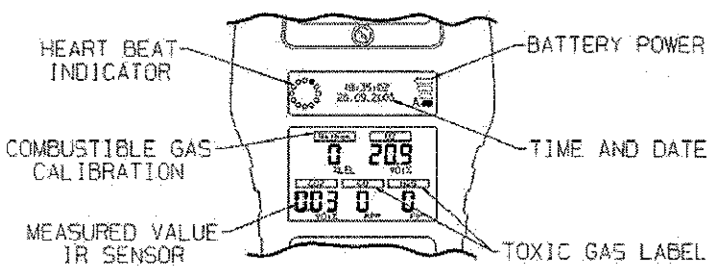

Figure 3-3. Heartbeat, Time & Date, and Battery Life Indicator

- The Heartbeat Indicator circles continuously to notify the user the instrument is ON and operating when Heartbeat is activated.

Time & Date indicator (see FIGURE 3-3)

- The current time (24-hour format) and date (MM/DD/YEAR) continuously displays in the upper portion of the screen.

Battery Life Indicator (see FIGURE 3-3)

- The battery condition icon continuously displays in the upper portion of the screen, regardless of the selected page.
- As the battery charge dissipates, segments of the battery icon go blank until only the outline of the icon remains.

Battery Warning

- A Battery Warning indicates that a nominal 20 minutes of operation remain before instrument batteries are completely depleted.

  NOTE: Duration of remaining instrument operation during Battery Warning depends on:

    - Ambient temperatures (The battery warning is likely to be shorter in colder temperatures, particularly with alkaline batteries)
    - Whether the battery warning is reset (it comes ON again every five minutes).

- When the Orion plus Multigas Detector goes into Battery Warning:
  - Battery Life indicator flashes
  - Alarm sounds
  - Alarm lights flash.
- To silence the Battery Warning, push the RESET button.
- The Orion plus Multigas Detector continues to operate until the instrument is turned OFF or battery shutdown occurs.

Battery Shutdown

When the batteries can no longer operate the instrument, the instrument goes into Battery Shutdown mode:

- Battery Indicator remains ON

- Alarm sounds continuously
- Alarm lights flash
- No other pages can be viewed
- After approximately five minutes, the unit automatically turns OFF.

⚠ WARNING

When Battery Shutdown condition sounds, stop using the instrument; it can no longer alert you of potential hazards since it does not have enough power to operate properly. You must:

1. Leave the area immediately.

2. Turn OFF the instrument if it is ON.

3. Report to the person responsible for maintenance.

4. Replace or recharge the battery pack.

Failure to follow this procedure, could result in serious personal injury or death.

For Alkaline Battery packs, replace batteries when the "Battery Low" or "Battery Shutdown" alarms occur. When replacing alkaline batteries, replace ALL batteries with fresh ones at the same time. Do not mix new and partially-discharged batteries. If the batteries are improperly replaced or improperly mixed, the "Battery Low" and "Battery Shutdown" alarms may fail to function, which could result in serious personal injury or death.

Do not use rechargeable batteries in Alkaline Battery Packs. The Alkaline battery warning and alarm setpoints are not optimized for rechargeable batteries. The low battery warning and alarm could occur too quickly to be noticed. Using rechargeable batteries in the Alkaline battery pack could result in serious personal injury or death.

NOTE: The instrument recognizes the type of installed battery pack (rechargeable NiMH or alkaline) and automatically adjusts the low battery warning and alarm setpoints.

⚠ CAUTION

During "Battery Low" condition, prepare to exit the work area since the instrument could go into "Battery Shutdown" at any time, resulting in loss of sensor function. Depending on the age of the batteries, ambient temperature and other conditions, the instrument "Battery Low" and "Battery Shutdown" times could be shorter than anticipated.

⚠ WARNING

Recharge or replace the batteries when the "Battery Low" or "Battery Shutdown" conditions occur.

Do not reuse a NiMH battery without recharging, even if the battery regains some charge after a period of non-use.

Verifying Pump Operation

1. Turn ON the Orion plus Multigas Detector.
   - The pump motor starts fast and then slows down as the instrument adjusts the power to run the pump.
2. Once gas readings are displayed, plug the free end of the sampling line or probe.
   - The pump motor shuts down and an alarm sounds.
   - The 'Heartbeat' stops circling and displays a "P" in the circle
   - A clear message appears in the display with 'on-line' instructions
   - The readings on the display may change.
3. When the pump inlet, sample line or probe is blocked, the pump alarm must activate. If the alarm does not activate:
   a. Check the pump, sample line, and probe for leaks.
   b. Once leak is fixed, recheck pump alarm by blocking the flow.
4. Check the pump before each day's use.

⚠ WARNING

Do not use the pump, sample line, or probe unless the pump alarm activates when the flow is blocked. Lack of an alarm is an indication that a sample may not be drawn to the sensors, which could cause inaccurate readings. Failure to follow the above can result in serious personal injury or death.

⚠ WARNING

Never let the end of the sampling line touch or go under any liquid surface. If liquid is sucked into the instrument, readings will be inaccurate and the instrument could be damaged.

5. Press the RESET button to reset the alarm and restart the pump.

During operation, a pump alarm may occur when the:

- Flow system is blocked
- Pump is inoperative
- Sample lines are attached or removed.

To Clear an Alarm

1. Correct any flow blockage.
2. Press the RESET button.
    - The Pump will now restart.

Response Check

The gas response check is simple and should complete in about one minute.

- Perform this response check before each day's use.

1. Turn ON the Orion plus Multigas Detector in clean, fresh air.
2. Verify that readings indicate no gas is present.
3. Attach the regulator to the cylinder.
4. Connect the tubing to the regulator.
5. Open the regulator valve.
    - The flow rate of the regulator is 0.25 lpm.
6. Attach the other end of tubing to the Orion plus pump inlet fitting.
    - The reading on the Orion plus Multigas Detector display should be within the limits stated on the calibration cylinder or limits determined by your company.
    - If necessary, change the cylinder to introduce other calibration gases.

- The Orion plus Multigas Detector also offers an option for a 'silent' response check with no audible and visual alarms triggered. For the 'silent' check, enter the 'Setup' mode (see Chapter 4,"Changing Instrument Settings") and, in the 'Calibration' menu, select the 'Calibration check' option.

Measuring Gas Concentrations

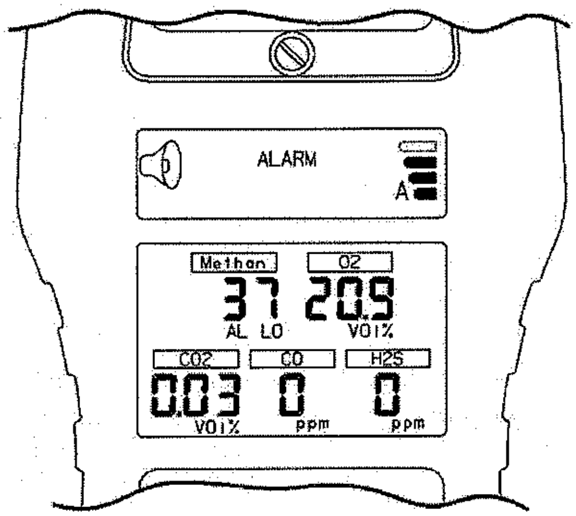

Figure 3-4. Instrument in LEL Alarm

The Orion plus Multigas Detector can be equipped to detect combustible gases in the atmosphere.

- Alarms sound when concentrations reach:
  - Low Alarm Setpoint, High Alarm Setpoint or
  - 100% LEL (Lower Explosive Limit).
- When the combustible gas indication reaches the Low Alarm Setpoint, the:
  - Alarm sounds and Alarm lights flash
  - Lo Alarm indication and % LEL label (located above the concentration) flashes; all other non-alarming gas readings move to the background.
- To silence the alarm, press the RESET button.

  NOTE: The alarm will stay silent if the alarm condition has cleared.
- When the combustible gas indication reaches the High Alarm Setpoint, the:
  - Alarm sounds and Alarm lights flash at a higher frequency

- High Alarm indication and % LEL label (located above the concentration) flashes; all other non-alarming gas readings move to the background.

- To silence the alarm, press the RESET button.

  NOTE: This alarm cannot be reset with RESET button until the condition is cleared.

- When the combustible gas indication reaches 125% LEL, the:
  - LockAlarm circuit locks the combustible gas reading and alarm
  - Alarm sounds
  - Alarm lights flash
  - Overrange message appears on the display.
- This alarm cannot be reset with the CHANGE/RESET button.

⚠ WARNING

If the overrange LEL alarm condition is reached, you may be in a life-threatening situation; there is enough gas in the atmosphere for an explosion to occur. In addition, any rapid up-scale reading followed by a declining or erratic reading can also be an indication that there is enough gas for an explosion. If either of these indications occur, leave and move away from the contaminated area immediately. Failure to follow this warning can result in serious personal injury or death.

- After moving to a safe, fresh-air environment, reset the alarm by turning OFF the instrument and turning it ON again.

Oxygen Measurements

The Orion plus Multigas Detector can be equipped to detect the amount of oxygen in the atmosphere.

- Two conditions, depending on setpoints, can trigger the alarm:
  - Too little oxygen (deficient)
  - Too much oxygen (enriched).
- When the alarm setpoint is reached for either of the above:
  - Alarm sounds and Alarm lights flash
  - Hi or Lo Alarm indication and % O_2 label above the concentration flashes; all other non-alarming gas readings move to the background.

Toxic Gas Measurements

The Orion plus Multigas Detector can be equipped to detect specific toxic gases.

When the Low alarm setpoint is reached for any toxic gas:

- Alarm sounds and Alarm lights flash
- Lo Alarm indication and gas label above the concentration flashes; all other non-alarming gas readings move to the background.

To silence the alarm, press the RESET button.

NOTE: The alarm will stay silent if the alarm condition has cleared.

When the toxic gas indication reaches the High Alarm Setpoint, the:

- Alarm sounds and Alarm lights flash at higher frequency
- Hi Alarm indication and gas label (located above the concentration) flashes; all other non-alarming gas readings move to the background.

NOTE: This alarm cannot be reset with the RESET button until the condition is cleared.

⚠ WARNING

If the Oxygen or Toxic Gas alarm condition is reached while using the instrument as a personal or area monitor, leave the area immediately; the ambient condition has reached a pre-set alarm level. If using the instrument as an inspection device, do not enter the area without proper protection. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

Viewing Optional Displays

- Press the PAGE button to move to Minimum Readings (MINIMUM).
  - This page shows the lowest level of oxygen recorded by the Orion plus Multigas Detector since Turn-ON.

Peak Readings (MAXIMUM)

- The Maximum flag appears in the upper portion of the display to show the highest levels of gas recorded by the Orion plus Multigas Detector since:
  - Turn-ON
  - Short Term Exposure Limits (STEL)
    - The STEL flag appears in the upper portion of the display to show the average exposure over a 15-minute period.
- When the amount of gas detected by the Orion plus Multigas Detector is greater than the STEL limit, the:
  - Alarm sounds and Alarm lights flash
  - STEL flag flashes.
- The STEL alarm is calculated over a 15-minute exposure. Calculation examples are as follows:

Assume the Orion plus Multigas Detector has been running for at least 15 minutes.

- 10-minute exposure of 35 PPM
  5-minute exposure of 5 PPM:

$$\frac{(10 \text{ minutes} \times 35 \text{ PPM}) + (5 \text{ minutes} \times 5 \text{ PPM})}{15 \text{ minutes}} = 25 \text{ PPM}$$

Assume the Orion plus Multigas Detector was turned on five minutes ago.

- 5-minute exposure of 15 PPM:

$$\frac{(5 \text{ minutes} \times 15 \text{ PPM}) + (10 \text{ minutes} \times 0 \text{ PPM})}{15 \text{ minutes}} = 5 \text{ PPM}$$

Time Weighted Average (TWA)

- The TWA flag appears in the upper portion of the display to show the average exposure since the TWA reading was reset.
- When the amount of gas detected by the Orion plus Multigas Detector is greater than the eight-hour TWA limit, the:
  - Alarm Sounds and Alarm Lights Flash
  - TWA flag flashes.

The TWA alarm is calculated over an eight-hour exposure. Calculation examples are as follows:

- 1-hour exposure of 50 PPM:

$$\frac{(1 \text{ hour} \times 50 \text{ PPM}) + (7 \text{ hours} \times 0 \text{ PPM})}{8 \text{ hours}} = 6.25 \text{ PPM}$$

- 12-hour exposure of 100 PPM:

$$\frac{(12 \text{ hours} \times 100 \text{ PPM})}{8 \text{ hours}} = 150 \text{ PPM}$$

NOTE: The accumulated reading is always divided by eight hours.

⚠ WARNING

If the STEL or TWA alarm condition is reached while using the instrument as a personal or area monitor, leave the contaminated area immediately; the ambient gas concentration has reached the preset STEL or TWA alarm level. Failure to follow this warning will cause over-exposure to toxic gases, which can result in serious personal injury or death.

Turning OFF the Orion plus Multigas Detector

Push and Hold the ON-OFF button for five seconds.

- Gas readings end and the Hourglass displays.

NOTE: Releasing the ON-OFF/PAGE button before the five seconds elapse returns the instrument to the Measure page.

Chapter 4, Setting up the Multigas Detector

Power Systems

- The Orion plus Multigas Detector is supplied with a NiMH battery pack or an optional replaceable cell, alkaline battery pack.
- See TABLE 4-1 for nominal run times by battery type.

Table 4-1.
Approximate Battery Run Times (20°C)

BATTERY TYPE	HOURS (WITH PUMP)
NiMH	10
Alkaline	6

In colder temperatures, battery output may be severely reduced. See TABLE 4-2 for capacity reductions expected for alkaline batteries at these temperatures.

Table 4-2.
Capacity Reductions
Expected for Batteries at Colder Temperatures

TEMPERATURE	AA ALKALINE
21°C (70°F)	None
0°C (32°F)	25%
-10°C (14°F)	60%

Battery Pack Removal

To remove the battery pack from the Orion plus Multigas Detector:

1. Remove the two screws from the bottom corner of the battery pack.
2. Gently pull out the pack by lifting the bottom out of its recess; then, slide it down.

Battery Charging (NiMH Battery Pack Only)

Charge the Orion plus Multigas Detector NiMH battery packs by using the Orion plus Fast Charger supplied with the instrument.

⚠ CAUTION

Use of any charger, other than the Fast Charger supplied with the instrument, may damage or improperly charge the batteries.

- The Orion plus Multigas Detector must be turned OFF, or the battery pack must be removed from the instrument, prior to charging.
- The charger is capable of charging a completely depleted pack in two hours in normal, room-temperature environments.

NOTE: Allow very cold battery packs to stabilize for 1/2-hour at room temperature before attempting to charge.

To Charge the Battery Pack

- Align and connect the charger cable plug and battery pack charging jack using the white alignment markers located on the charger plug and the back of the battery pack or use the charger cradle.
- Charger status is indicated by the LED color:
  - **Amber**
    The charge is pending; LED remains amber until the pack is ready to be charged.
  - **Red**
    Charging is in process.
  - **Green**
    Charging is complete; the pack is fully charged and ready for use.

- **Red Flashing**
  Failure mode; remove battery pack from charger.
- **LED OFF**
  No battery pack is connected.

To Charge the Battery Pack (Vehicle Charger P/N 10034276)

- Connect the:
  - input cable assembly to the automobile lighter and
  - input to the charger assembly.
- Align and connect the charger cable plug and battery pack charging jack by using the white alignment markers located on the charger plug and the back of the battery pack.
- Charger status is indicated by the LED color:
  - **Yellow**
    Charge pending/Fault
  - **Solid Red**
    Charging is in process
  - **Solid Green**
    Charge complete.

Once battery pack is charged, it:

- Can be disconnected from the charger
- Is ready for immediate use.

Alkaline Battery Pack

- The Orion plus Multigas Detector Replaceable battery pack can be used as a:
  - Full-time battery pack or
  - Backup power source.
- See TABLE 4-3 for batteries approved for use in the Orion plus alkaline battery pack.

Table 4-3.
Batteries Approved for use in the Orion plus Alkaline Battery Pack

BATTERY	UL	EUROPE	AUSTRALIA
DURACELL MN1500	•	•	•
VARTA 4006	•	•	
Energizer E91	•		•

To Replace the Batteries

1. Remove battery pack from the instrument by removing the two screws located in the bottom corners of the battery pack.
2. Gently lift the pack out of its recess and pull it out.
3. Using the supplied hex key, loosen the single screw that holds the plastic battery cover to the battery pack.
4. Remove the plastic cover, exposing the replaceable batteries.
5. Remove the depleted batteries.

   NOTE: Follow local regulations regarding battery disposal.
6. Install the new batteries, observing the direction of the positive (+) battery terminal. The instrument will not operate if cells are reversed.
7. Replace the plastic battery cover and tighten the screw.
8. Re-install the battery pack on the instrument.

Changing Instrument Settings

- Many of the Orion plus Multigas Detector options can be set using the buttons on the front of the instrument.
- The MSA Orion plus LINK software can be used to set most of the instrument selections, including some that cannot be changed from the instrument's front panel buttons.

1. To access instrument Setup mode, simultaneously press the PAGE and RESET buttons until "Password" appears on the display.
2. Enter the following sequence:
   - PAGE, ON/OFF, RESET, ON/OFF, PAGE
   - You are now in the Setup menu, on the top menu "calibration"; there are five top menus which can be accessed using the scroll (PAGE/RESET) and OK (ON/OFF) buttons

- See TABLE 4-4 for available selections and methods for changing these selections.

Table 4-4.
Available Instrument Selections and Methods for Changing Selections

OPTION	Orion plus FRONT-PANEL BUTTONS	ORION PLUS LINK
Viewing alarm set-points	●	●
Changing alarm set-points	●	●
Setting Datalog Intervals	●	
Setting calibration	●	
Password Change		●
Setting Date/Time	●	
Set Contrast	●	
Set Language (English/German)	●	●
Add Remote Sensors		●

Chapter 5, Instrument Setup and Calibration

⚠ WARNING

Attention! Special conditions with toxic gases!

If the instrument is to be checked or calibrated for toxic gases, prerequisites are required; otherwise, incorrect calibration would result in incorrect instrument operation.

Toxic gases (e.g., chlorine, ammonia, ozone) have the property of diffusing into rubber and plastic tubes so the volume of test gas available in the instrument would no longer be sufficient to correctly perform instrument calibration.

For this reason, when calibrating the instrument with toxic gases, certain prerequisites are required:

- a special pressure reducer
- short connection tubes between the pressure reducer and the instrument (approximately one inch)
- connection tubes made from a material which does not absorb the test gases (e.g., Teflon).

NOTE: If using normal tubes and pressure reducers, expose them to the relevant test gas for an extended time period.

For example:
for chlorine, allow the entire contents of a test gas cylinder to flow through the tubes and the pressure reducer.

Calibrating the Orion plus Multigas Detector

The Orion plus Multigas Detector is equipped with a password-accessible autocalibration feature to prevent unauthorized access to calibration. This autocalibration function will only operate with configurations shown in TABLE 5-1.

The Autocalibration sequence resets, instrument zeroes, and adjusts sensor calibration for known concentrations of calibration gases.

Table 5-1. Autocalibration and Required Calibration Cylinders

SENSORS	EXPECTED GAS CONCENTRATION	FIVE GAS CYLINDER	FOUR GAS CYLINDER
	58 Liters	P/N 10050744	P/N 804770
	34 Liters	P/N 10058022	P/N 711058
Combustible	58% LEL	●	●
Oxygen	15%	●	●
Carbon Monoxide	300 ppm	●	●
Hydrogen Sulfide	10 ppm	●	●
Carbon Dioxide	2.5% Vol	●	

To Calibrate the Orion plus Multigas Detector

1. Turn ON instrument and verify that battery is sufficiently charged.
2. To access Instrument Setup mode, simultaneously press the PAGE and RESET buttons until "Password" appears on the display.

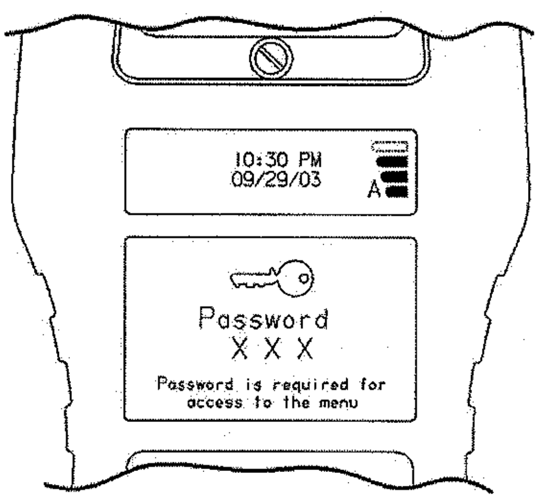

Figure 5-1. Password Screen

3. Enter the following sequence:
   - PAGE, ON/OFF, RESET, ON/OFF, PAGE.
     - User is now:
       - in the Setup menu
       - at the top Menu,"calibration".
     - There are five top menus accessible by using the:
       - Scroll (PAGE, RESET) and
       - OK (ON/OFF) buttons.
     - The five top menus in the Setup menu are:
       - Calibration
       - Alarm Setup
       - Instrument Setup
       - Turn Off Instrument
       - Go Back to Measurement.

Calibration Mode

4. To enter this page, press OK by scrolling with the PAGE and RESET buttons.
5. It is now possible to access the following sub-menus:
   - Calibration Multiple Sensors
     - 5 sensor calibration (see TABLE 5-1)
     - 4 sensor calibration (see TABLE 5-1)
   - Calibration Single Sensor
   - Fresh Air Setup
   - Calibration Check
   - Go Back to Previous Menu.

   NOTE: The procedure is similar for all menus.

- The following describe the 4 sensor calibration procedure.

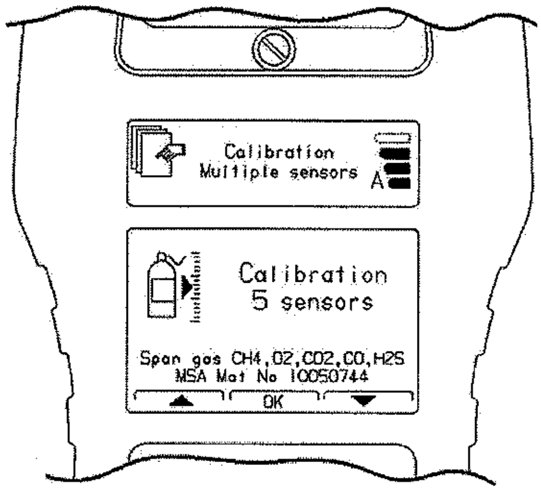

Figure 5-2. Multi Sensor Calibration Screen

Calibration Multiple Sensors

1. Access with OK; choose (PAGE, RESET) for:
   - 5 sensor calibration (see TABLE 5-1) or
   - 4 sensor calibration (see TABLE 5-1)
2. Access with OK.
   - Instrument displays list of required gases and concentrations.
3. Press NEXT for zero Calibration.
   - Instrument displays 'Apply Fresh Air'.

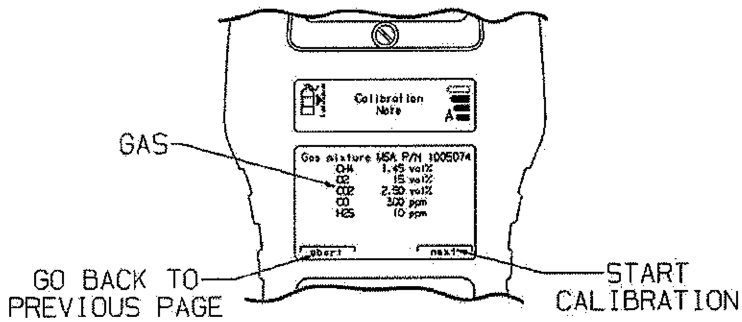

Figure 5-3. Gas Mixture Screen

4. Press:
    - ABORT to cancel
    - MEASURE to return to Measure mode
    - REPEAT to start FAS again
    - MENU to return to 4 sensor calibration
    - NEXT to perform FAS.
5. Press:
    - VALUE to see gas Value instead of gas Flag
    - ABORT to cancel FAS.
6. Press:
    - MEASURE to return to Measure mode
    - REPEAT to start FAS again
    - MENU to return to 4 sensor calibration.
        - If FAS is successful, instrument displays "Apply Span gas".
7 Press:
    - ABORT to cancel.
8. Press:
    - MEASURE to return to Measure mode
    - REPEAT to return to "Apply Span Gas"

- MENU to return to 4 sensor calibration
- NEXT to perform Calibration.

9. Press:
   - VALUE to see gas Value instead of gas Flag
   - ABORT to cancel Calibration.

10. Press:
    - MEASURE to return to Measure mode
    - REPEAT to start 4 sensor Calibration again
    - MENU to return to 4 sensor calibration.
      - If Calibration is successful, the instrument asks for confirmation.
      - If Calibration is not successful, user can:
        - REPEAT or
        - ABORT.

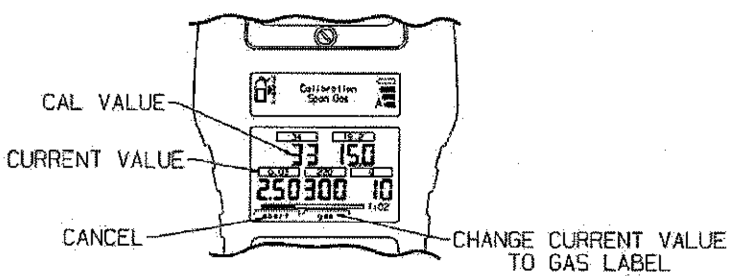

Figure 5-4. Calibration Page

Calibration Single Sensor

1. Access with OK.
2. Press NEXT and follow a procedure similar to that previously given under "Calibration Multiple Sensors".

   NOTE: After performing FAS, the unit will ask for Span gas; the calibration value can be adjusted in this mode.

Calibration Table

ORION Plus Echem sensor Calibration — Zero gas: Clean Fresh Air

Sensor	Range	Time Zero gas	Time Span gas	Cal gas Concentration	Display Read out
O2 Oxygen	0-25 Vol%	-	90 s	Clean Fresh Air (20.9 Vol % O2)	20.9 Vol%
CO Carbon Monoxide	0-300 ppm	60 s	90 s	10058022 /1005823 (58L) 300 ppm CO	300 ppm
H2S Hydrogen Sulphide	0-200 ppm	60 s	90 s	10058022 /1005823 (58L) 10 ppm H2S	10 ppm
NH3 Ammonia	0-100 ppm	60 s	240 s	711078 (34L) 25 ppm NH3 in N2	25 ppm
Cl2 Chlorine	0-10 ppm	60 s	180 s	806740 (58L) 10 ppm Cl2 in N2	10 ppm
SO2 Sulfur Dioxide	0-20 ppm	60 s	120 s	711070 (34L) 10 ppm SO2 in N2	10 ppm
NO2 Nitrogen Dioxide	0-20 ppm	60 s	180 s	711068 (34L) 10 ppm NO2 in Air	10 ppm
PH3 Phosphine	0-5 ppm	60 s	90 s	711066 (34L) 0.5 ppm PH3 in N2	0.5 ppm
ClO2 Chlorine Dioxide	0-1 ppm	60 s	180 s	711082 (34L) 2 ppm Cl2 / N2	0.6 ppm
O3 Ozone	0-1 ppm	60 s	240 s	711082 (34L) 2 ppm Cl2 / N2	2.4 ppm
HCN Hydrogen Cyanide	0-30 ppm	60 s	180 s	711072 (34L) 10 ppm HCN / N2	10 ppm
COCl2 Phosgene	0-1 ppm	60 s	240 s	711082 (34L) 2 ppm Cl2 / N2	0.8 ppm

ORION Plus IR sensor Calibration — Zero gas: Clean Fresh Air

Sensor	Range	Time Zero gas	Time Span gas	Cal gas Concentration	Display Read out
CO2 Carbon dioxide	0 - 10 Vol%	60 s	90 s	10058022/ 1005823 (58L) 2.5 Vol % CO2	2.5 Vol%
CO2 Carbon dioxide	0 - 50 Vol%	60 s	90 s	10081603 10% CO2 in N2	10 Vol%
C3H8 Propane	0 - 100 % LEL	60 s	90 s	493579 100L 0.6 Vol % C3H8 in Air	29% LEL
C3H8 Propane	0 - 25 Vol %	60 s	90 s	10081605 / 15% Propane in N2 10075802 /8Vol%C4H10 -> 11	15% 11.0 Vol%
C3H8 Propane	0 - 100 Vol %	60 s	90 s	10075803 / 8Vol % C3H8 -> 8 10075802 /8Vol%C4H10 -> 11	8.0 Vol% 11.0 Vol%
C4H10 n-Butane	0 - 25 Vol %	60 s	90 s	10075802/ 8 Vol% C4H10 in N2	8.0 Vol%
C4H10 n-Butane	0 - 100 Vol %	60 s	90 s	10081604 / 15% Butane in N2	15 Vol%
CH4 Methane	0 - 25 Vol %	60 s	90 s	2.5 % Vol CH4	2.5% Vol
CH4 Methane	0 - 100 Vol %	60 s	90 s	711014 (58L) 100 Vol % CH4 in N2	100 Vol%

Alarm Setup Mode

NOTE: Accessing the Instrument Setup mode leads you to the main Calibration mode page.

1. To access the 'Alarm Setup' page:
   - Press the scroll buttons (PAGE, RESET).
   - Press OK.
     - User is now in the 'Setup Alarm Lo' page.

'Setup Alarm Lo' Page

2. Press:
   - ABORT to cancel setup
   - REPEAT to return to 'Setup Alarm Lo' page
   - NEXT to access the main 'Alarm Setup' page
3. CHANGE setpoints with the PAGE and RESET buttons.
4. Confirm settings with the ON/OFF button.
   - NEXT will lead you to 'Setup Alarm Hi' page.

'Setup Alarm Hi' Page

5. In the 'Setup Alarm Hi' page, press:
   - ABORT to cancel setup
   - REPEAT to return to 'Setup Alarm Lo' page
   - NEXT to access the main 'Setup TWA Alarms' page
6. CHANGE setpoints with the PAGE and RESET buttons.
7. Confirm settings with the ON/OFF button.
   - NEXT leads to 'Setup TWA Alarms' page.

'Setup TWA Alarms' Page

- In 'Setup TWA Alarms', display asks 'Activate TWA Alarms?',

8. Press:
   - ABORT to cancel setup
   - REPEAT to return to 'Setup Alarm Lo' page

- NEXT to access the main 'Alarm Setup' page
- NO to Deactivate STEL and TWA Alarms
- YES to save this setting and move to 'Alarm Setup' page.

9. In 'Alarm Setup' page press:
   - NO to cancel
   - REPEAT to return to 'Setup Alarm Lo' again
   - NEXT to access the main 'Alarm Setup' page
   - YES to activate and move to 'Setup Alarm STEL' page.

'Setup Alarm STEL' Page

10. In 'Setup Alarm STEL', press:
    - NO to cancel
    - REPEAT to return to 'Setup Alarm Lo' again
    - NEXT to access the main 'Alarm Setup' page
11. CHANGE the STEL setpoints with the PAGE and RESET buttons.
12. Confirm the settings with the ON/OFF button.
    - NEXT will lead you to the 'Setup TWA Alarms' page.
13. In the 'Setup Alarm TWA', press:
    - ABORT to cancel setup
    - REPEAT to return to 'Setup Alarm Lo' page
    - NEXT to access the main 'Alarm Setup' page
14. CHANGE the TWA setpoints with the PAGE and RESET buttons.
15. Confirm the settings with the ON/OFF button.
    - NEXT leads to the question 'Save alarm setup?'
16. Press:
    - YES to save
    - NEXT to access the main 'Alarm Setup' page
    - NO to cancel the setup
    - REPEAT to restart 'Setup Alarm Lo'
    - NEXT to access the main 'Alarm Setup' page.

Instrument Setup Menu

NOTE: Accessing the Instrument Setup mode leads you to the main Calibration mode page.

1. To access the Instrument Setup page:
   - Press the scroll buttons (PAGE, RESET).
   - Press OK.
     - User is now in the 'Instrument setup' page.
     - the instrument displays the 'Time Setup' sub-menu

'Time Setup' Sub-Menu

2. Press:
   - OK to enter the Time Setup page
     - display asks, 'change time?'
3. Press:
   - NO to cancel and return to 'time Setup' page
   - YES to change
   - OK to confirm setting.
     - Display asks 'Save new time?'
4. Press:
   - YES to save and return to the 'Time setup' page
   - NO to cancel and return to the 'Time Setup' page
   - REPEAT to change time and date again.
     - 'Language' is the next sub-menu under 'instrument Setup'

'Language' Sub-Menu

5. Press OK to enter the Language sub-menu.
   - The display shows 'English'.
6. Press:
   - ABORT to return to the 'English' page
   - STORE to save and return to the 'Calibration' page
   - CHANGE to change to the 'Deutsche' page.

7. Press:

- 'SPEICHERN' to store
- 'ANDERN' to go back to 'English'
- 'ABBRUCH' to return to 'Language'
    - 'Heartbeat' is the next sub-menu under 'instrument Setup'.

'Heartbeat' Sub-Menu

7. Press:
    - OK to enter the Heartbeat sub-menu
        - The display shows 'Heartbeat ON'
    - OFF to:
        - Turn OFF the confidence beep and
        - Flash every 60 seconds
    - NEXT to return to 'Heartbeat' page
    - ABORT to return to 'Heartbeat' page
        - 'Contrast Setup' is the next sub-menu under Instrument Setup'.

'Contrast Setup' Sub-Menu

8. Press:
    - OK to enter the Contrast Setup sub-menu.

NOTE: Contrast automatically adjusts with temperature changes. However, low temperatures may cause poor display contrast; this can be manually adjusted in the Setup mode.

'Data Logging Interval' Sub-Menu

9. Press OK to enter the 'Data Logging Interval' sub menu
10. To change the interval to a setting between 15 seconds and 10 minutes, use the (PAGE, RESET) scroll buttons.
11. Press OK to confirm setting.
    - 'Data Logging Interval' is the next sub-menu under 'Instrument Setup'.
    - Use arrows to change settings; press OK to confirm settings

between 15 seconds, 30 seconds, 60 seconds, two minutes, five minutes, and 10 minutes.

- 'Go back to Previous Menu' is the next sub-menu under 'instrument Setup'.

'Go back to Previous Menu'

13. To return to the previous menu:
    - Press OK to confirm or
    - Scroll with PAGE, RESET between previous sub-menus.

Turn OFF Instrument (Main Menu)

- Press OK to turn OFF the instrument
- Scroll with PAGE, RESET between other menus.

Go Back to Measurement (Main Menu)

- Press OK to return to the Measuring page
- Scroll with PAGE, RESET between other menus.

Setting the Instrument Using the ORION Link Software

NOTE: The computer must be fitted with an Infrared Adaptor IrDA RS 232 (e.g. iFoundry IFSYS-8001A) and the corresponding software.

1. If not already done, connect the infrared adaptor to the computer and install the driver (see drivers and installation instructions for the infrared adaptor).

   NOTE: .NET-Framework by Microsoft® software must be installed on the computer.

2. If not already done, install the .NET-Framework by Microsoft software on the computer (software and installation instructions are on the supplied CD-ROM).
3. Install the ORION Link software on the computer (software and installation instructions are on the supplied CD-ROM).

Connecting Instrument to the PC

1. Turn ON the computer and open the ORION Link software.
2. Turn ON the instrument and wait until it is in the Measuring mode.
3. Locate the instrument about 1 inch away from the infrared adaptor (with input spigot pointing toward the infrared sensor when viewing the instrument from the rear).

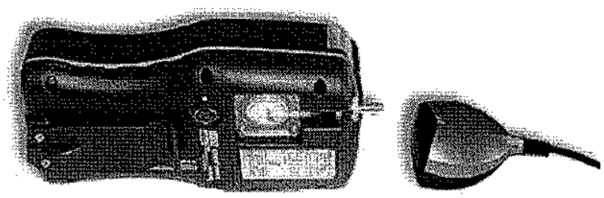

Figure 5-5. Attaching the Infrared Adaptor to the Instrument

4. On the Start screen of the ORION Link software, select CONNECT INSTRUMENT.
5. On the window that opens, select the:
   - interface (COM1, COM2 or others) connected to the infrared adaptor (FIGURE 5-6)
   - scope of information:
     - Instrument information
     - Sensor data and settings
     - Stored event data (over a specific time period)
     - Stored measured values (over a specific time period)

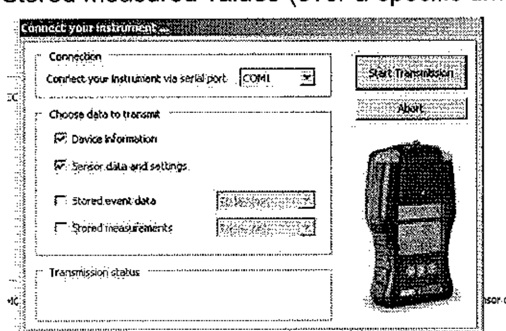

Figure 5-6. Connecting the Instrument

6. Connect the instrument by clicking on the CONNECT INSTRUMENT button.
    - The following Welcome screen appears:

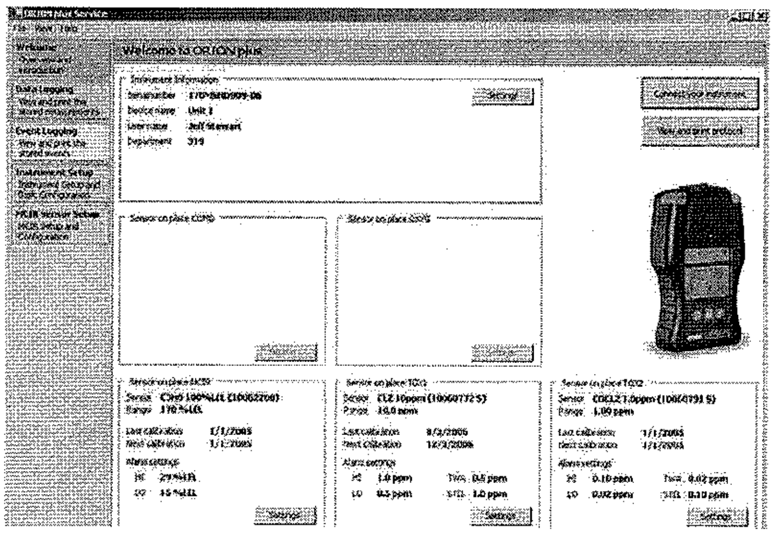

Figure 5-7. Welcome to ORION plus

- The CONNECT INSTRUMENT button can be used to reestablish an interrupted connection.
- The CREATE PROTOCOL button can be used to store all the instrument data.
- FIGURE 5-7 displays the:
    - instrument data
    - information concerning individual sensors.
- After pressing the SETTINGS button, the user can change:
    - settings for each sensor individually (if the required areas are adjustable)
    - alarm settings for installed sensors.

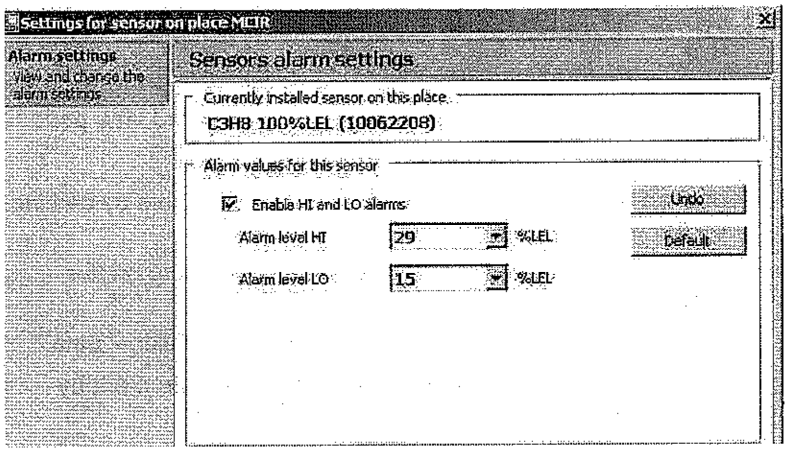

Figure 5-8. Alarm Settings

- The FIGURE 5-8 screen shows the:
  - sensors
  - alarm thresholds for these sensors.
- By selecting the options you can activate or deactivate the alarm.
  - This can only be done for *both* alarm thresholds *together*.
- The alarm thresholds:
  - can be changed to suit the user's requirements and
  - transmitted to the instrument by closing the window.
- By clicking on the relevant button the user can:
  - cancel the changes made or
  - set the values to a standard setting.
- By using the buttons in the navigation bar (FIGURE 5-7) the user can access other program areas, such as:
  - Data storage – display and store the instrument data
  - Event storage – display and store the event data
  - Instrument settings – instrument settings and configuration
  - MCIR settings – MCIR settings and configuration.

NOTE: The program areas, instrument settings and MCIR settings are only accessible with valid authorization.
For access to the area MCIR settings, the corresponding sensor must be installed.

Data Log

- In this window, the user can:
  - view all stored measurement data for the selected time period
  - view instrument data
  - convert and store the measurement data as a table by clicking on the STORE TABLE button
  - delete all the stored measurement data by clicking on the DELETE DATA button

    NOTE: It is not possible to delete selected individual data.
  - re-establish an interrupted connection to the instrument by pressing the CONNECT INSTRUMENT button.

Event Log

- In this window, the user can:
  - view all stored measurement data for the selected time period
  - view instrument data
  - convert and store the measurement data as a table by clicking on the STORE TABLE button
  - re-establish an interrupted connection to the instrument by pressing the CONNECT INSTRUMENT button.

Area Instrument Settings

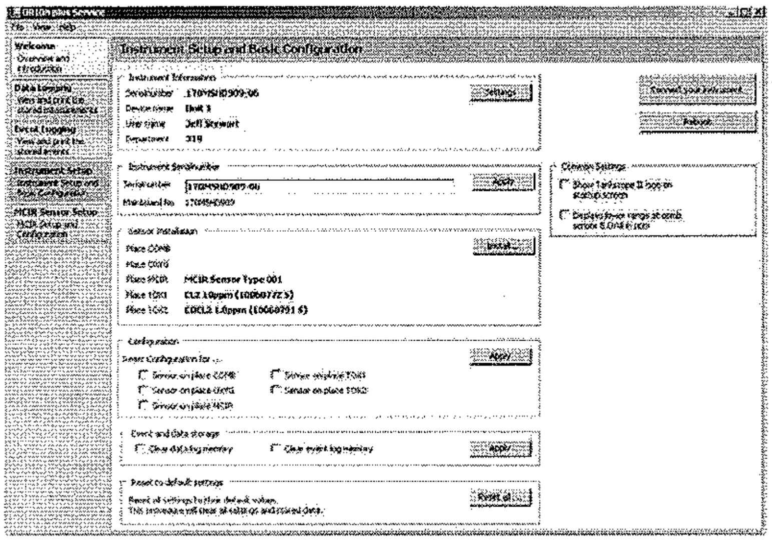

Figure 5-9. Instrument Settings and Configuration

- This window provides extended instrument settings and configuration.
- Certain functions are only accessible by the group of persons authorized by MSA.
- The available options are:
  - Display and modify the instrument information
  - Display the instrument serial number
  - Install the sensors
  - Reset the sensors
  - Delete the data and event storage .
- To reset all instrument data to the factory setting, click on the RESET button.

- By clicking on the SETTINGS button in the area instrument information (FIGURE 5-11), the "Instrument Settings" window appears:

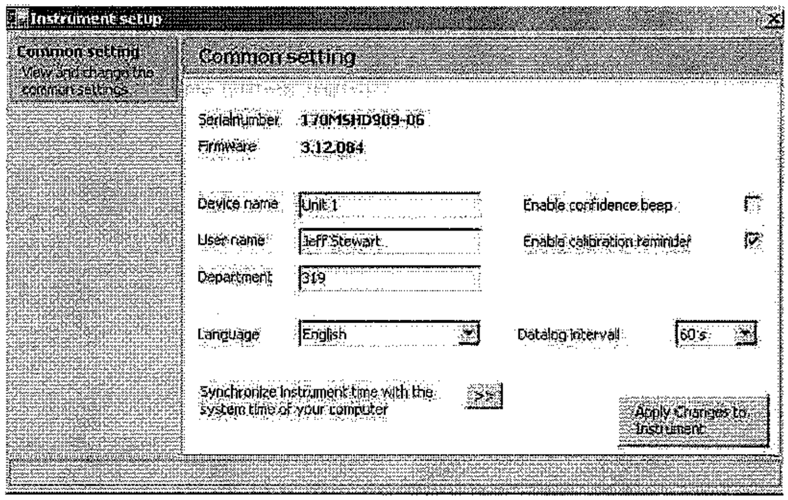

Figure 5-10. Instrument Settings

- This window displays the instrument serial number and additional information applicable to the instrument:
  - Instrument name
  - User, Department
  - Language and
  - Data storage interval.
- The user can:
  - change the information on the input masks provided for this purpose.
  - activate or be reminded by a sound when instrument calibration is required.
- All data is transmitted to the instrument by clicking on the TRANSMIT CHANGES button, .
- After the changes are transmitted, the instrument performs a REBOOT (automatically switches OFF and ON again).

Chapter 6, Warranty, Maintenance, and Troubleshooting

MSA Portable Instrument Warranty

1. Warranty-

ITEM	WARRANTY PERIOD
Chassis and electronics	Two years (MSA will support product for five years after production ends)
Sensors	Varies (see TABLE 7-2)
Pump and drive unit	Two years
Rechargeable batteries	Two years

This warranty does not cover fuses. Certain other accessories not specifically listed here may have different warranty periods. This warranty is valid only if the product is maintained and used in accordance with Seller's instructions and/or recommendations. The Seller shall be released from all obligations under this warranty in the event repairs or modifications are made by persons other than its own or authorized service personnel or if the warranty claim results from physical abuse or misuse of the product. No agent, employee or representative of the Seller has any authority to bind the Seller to any affirmation, representation or warranty concerning this product. Seller makes no warranty concerning components or accessories not manufactured by the Seller, but will pass on to the Purchaser all warranties of manufacturers of such components. **THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, AND IS STRICTLY LIMITED TO THE TERMS HEREOF. SELLER SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.**

2. **Exclusive Remedy-** It is expressly agreed that Purchaser's sole and exclusive remedy for breach of the above warranty, for any tortious conduct of Seller, or for any other cause of action, shall be the repair and/or replacement at Seller's option, of any equipment or parts thereof, which after examination by Seller is proven to be defective. Replacement equipment and/or parts will be provided at no cost to Purchaser, F.O.B. Seller's Plant. Failure of Seller to successfully repair any nonconforming product shall not cause the remedy established hereby to fail of its essential purpose.

3. **Exclusion of Consequential Damages-** Purchaser specifically understands and agrees that under no circumstances will seller be liable to purchaser for economic, special, incidental or consequential damages or losses of any kind whatsoever, including but not limited to, loss of anticipated profits and any other loss caused by reason of nonoperation of the goods. This exclusion is applicable to claims for breach of warranty, tortious conduct or any other cause of action against seller.

Cleaning and Periodic Checks

As with all electronic equipment, the Orion plus Multigas Detector will operate only if it is properly maintained.

⚠ WARNING

Repair or alteration of the Orion plus Multigas Detector, beyond the procedures described in this manual or by anyone other than a person authorized by MSA, could cause the instrument to fail to perform properly. Use only genuine MSA replacement parts when performing any maintenance procedures described in this manual. Substitution of components can seriously impair instrument performance, alter intrinsic safety characteristics or void agency approvals.

FAILURE TO FOLLOW THIS WARNING CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

Cleaning and Routine Care

Periodically clean the Orion plus Multigas Detector case with a soft damp cloth.

1. Remove the sensor cover plate, sensor membrane, and sensor cover gasket (see Chapter 8, FIGURE 8-1)
2. Clean sensor plate holes with a paper clip, wire, or similar device. The holes may also be cleaned with oil-free compressed air.
3. Replace sensor membrane with a new one.

⚠ WARNING

Do not attempt to clean the sensor cover plate while it is in place; sensor damage may occur. The tops of sensors are very fragile; do not touch or apply pressure to the tops of any sensors. If a sensor is damaged, it can cause the unit to give false readings.The sensor cover plate contains holes for four sensors. In instruments with less than four sensors, some of the holes are permanently blocked with special sealing membranes. Do not puncture these membranes; erroneous gas readings can result.

Checking The Pump Inlet Filter

Orion plus Multigas Detectors ordered with the internal pump contain a filtering system to protect the pump from particles and water in the sample air. If the filter becomes clogged, the sample flow may be blocked, or and extra load may be placed on the pump; therefore, check the filter regularly.

The frequency of checks should depend on amount of pump usage and concentration of particles allowed to enter the pump. In dirty applications, replace the dust filter every 200 hours.

Replacing the Filters

⚠ CAUTION

When replacing external dust and water filters, prevent any dust or dirt around the filter housing from entering the pump housing. Dust or dirt in the pump unit may impede pump operation.

Dust and Water Filter (see FIGURE 8-2 and TABLE 8-2)

1. Remove the four screws (24) from the clear filter housing (23) on the back of the instrument.
2. Remove fibrous filter (21) from the recess on filter housing.
3. Carefully install the new filter in the filter housing recess.
4. Re-install the filter housing.

NOTE: When replacing filter, carefully handle new filter by the edges only, as it is easily torn. Install filters in correct order.

4. Replace the O-ring, being sure to press gently down on top of the water filter.
5. Replace the cover and screws.

Probe Filter

- The MSA sampling probe contains a filter to:
  - block dust and dirt
  - block the passage of water.
- If the probe tip is accidentally submerged in water, the filter prevents the water from reaching the internal pump. The filter is not designed to stop other liquids, such as gasoline or alcohols.

To Replace the Probe Filter

1. Grasp the probe handle by the base and guard.
2. Push the cap section toward the other two and turn clockwise.The spring pushes the sections apart.
3. Grasp and spin the wand clockwise while pulling to disengage.
4. Remove the water trap filter (P/N 801582) and replace.

Storage

- When not in use, store your Orion plus Multigas Detector in a safe, dry place between -5° and 40°C (23° and 104 °F).
- The Orion plus Multigas Detector with the NiMH rechargeable battery pack can be stored on charge indefinitely.

⚠ WARNING

After storage, always recheck instrument calibration before use. During storage, sensors may drift or become inoperative and may not provide warnings of dangers to the health and lives of users.

Shipment

1. Remove battery pack before shipment. When returning the Orion plus Multigas Detector for repairs, disconnect the normally used battery pack from unit, and include it in the container.

2. Pack the Orion plus Multigas Detector in its original shipping container with suitable padding. If the original container is unavailable, an equivalent container may be substituted. Seal instrument in a plastic bag to protect it from moisture. Use sufficient padding to protect it from the rigors of handling. Damage due to improper packaging or damage in shipment is not covered by the instrument's warranty.

Troubleshooting

The Orion plus Multigas Detector will operate reliably for years when cared for and maintained properly. If the instrument becomes inoperative, it typically displays the error message with corrective action in clear language. You may return nonoperative instruments to MSA for repair.

- **Instrument Division**
  Repair and Service Department
  1000 Cranberry Woods Drive
  Cranberry Township, PA 16066-5207
  1-800-MSA-INST

To contact MSA International, please call:

- **1-412-967-3000 or 1-800-MSA-7777**.

Table 6-1. Troubleshooting Guidelines

PROBLEM	ACTION
Does not turn ON	Recharge (if applicable) or replace battery. See Chapter 6
Battery pack does not hold charge	Replace battery. See Chapter 6
Sensor does not calibrate	Replace sensor. See Chapter 6
IR Sensor Error	If temperature too cold, allow instrument to stabilize within normal temperature range before turning ON. If Error remains, contact the MSA Repair Center
Pump alarm	Check for leaks/blocks, replace dust and water filters. See Chapter 3
Sensor missing	Check installation of sensor/replace sensor. See Chapter 6
RAM Error	Contact MSA
ROM Error	Contact MSA
Memory Error	Contact MSA
Battery type not recognized	Change the battery pack or have the instrument checked by MSA
Device restarts automatically	If this occurs repeatedly, arrange for service by MSA
▲ or ▼ next to the measurement unit	Measurement above or below measuring range; calibration required
Fresh Air Setup error	Supply fresh air (not measuring gas) and repeat; if error recurs, calibration is required
Test gas error	Check the gauge on test gas regulator. Set the correct test gas concentration; if message recurs, replace the sensor

In all of the above cases and for any other problems, the Orion plus Multigas Detector may be returned to MSA for repairs.

Repair Procedures

Battery Pack Replacement

Remove the Battery Pack

1. Remove the two battery mounting screws on the back of the instrument.
2. Pull out the battery pack by gripping it at the edge of the battery pack case and pulling it away from the unit.

Replace the Battery Pack

3. Insert the front of the battery pack under the lip on the case and snap the bottom of the battery pack into the case.

4. Install and tighten the battery mounting screws.

Sensor Replacement

1. Verify that the instrument is turned OFF; remove battery pack.
2. Remove pump cover by removing the screw with a 1/16" hex key.
3. Remove the sensor cover screws and cover.
4. Gently lift out sensor to be replaced; properly dispose of sensor.

   NOTE: Sensor positions cannot be changed. Each sensor location is identified by a label in the bottom of each sensor well. When replacing a sensor, ensure that the gas type printed on the sensor label matches the sensor identification label in the instrument.

5. If replacement sensor is equipped with a shorting plate, clip or wire attached to its pins, remove plate, clip or wire before inserting the replacement sensor.
6. Carefully align the new sensor contact pins with the sockets on the printed circuit board.
7. Press the new sensor into place.
8. Replace the sensor gasket and sensor cover.
9. Re-install the screws to hold down the sensor cover.

   NOTE: Any repair beyond this manual (IR sensor, Main board, etc.) requires special training and can only be performed by qualified and authorized repair centers.

⚠ WARNING

Verification of calibration response is required (some toxic sensors require more than five hours to stabilize); otherwise, the instrument will not perform as required, and persons relying on this product for their safety could sustain serious personal injury or death.

Chapter 7, Performance Specifications

Table 7-1. Certifications

HAZARDOUS LOCATIONS	**US**	UL 913 for Class 1, Div. 1, Groups A, B, C, and D
	CANADA	CSA C22.2 No. 157 for Class 1, Div. 1,Groups A, B, C, and D
	EUROPE	EN 50 014/ EN 50 018/EN 50 019/ EN 50 020 EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C
	AUSTRALIA	AS/NZS 60079-11 ExiasIIC -20°C to +50°C
EMC/RFI	**US**	47 CFR, part 15
	EUROPE	EN 50270 Type 2 EN 61000-6-3
	AUSTRALIA	C-tick emissions (CSPR11)
PERFORMANCE	**CANADA**	CSA C22.2 No. 152 for Methane only
	EUROPE	IEC 529 IP54 min., EN 50 271/ EN 50 054 EN 50 057/ EN 50 104 EN 45 544
	AUSTRALIA	AS/NZS 61779 -1/61779-4
SAFETY	**EUROPE**	CE: LVD (low voltage directive), EN61010-1 for chargers and accessories requiring greater than 50 VAC or 75 VDC
ATEX	**EUROPE**	EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C
		Directive 94/9/CE
	Ex	BVS 03 ATEX E 27OX II2G EEx ia d e IIC T4 (T3 Varta Alkaline AA) -20 °C to +50°C

Table 7-2. Instrument Specifications

TEMPERATURE RANGE	Normal	0 to 40°C
	Extended*	-20 to 50°C
WARM-UP TIME		two minutes

***NOTE:** Extended temperature range indicates that gas readings may vary slightly if calibrated at room temperature. For optimal performance, it is recommended that the instrument be calibrated at temperature of use.

MEASUREMENT METHODS	**COMBUSTIBLE GAS**	Catalytic Sensor
	OXYGEN	Electrochemical Sensor
	TOXIC GASES	Electrochemical Sensors/IR Sensor
WEIGHT	410 g (instrument with battery pack)	
DIMENSIONS	165 x 92 x 66 mm (L x B x H)	
BATTERY TYPE	Rechargeable NiMH battery pack	
BATTERY LIFE	NiMH: 11 h	
CHARGING TIME	≤ 3 h with the MSA Fast Charger (100-250 VAC)	
WARM UP TIME	2 minutes	
TEMPERATURE RANGE	-20°C to +50°C, Storage from -5°C to +40°C	
HUMIDITY RANGE	15 - 90% rel. humidity, non condensing, short term 5% - 95% rel. humidity	
ATMOSPHERIC PRESSURE RANGE	800 to 1200 HPa	
FLOW RATE	0.2 to 0.5 l/min	
DUST AND SPRAY PROTECTION	IP 54	
WARRANTY	2 years for housing, electronics, rechargeable batteries and pump 2 years for IR, LEL, O_2, H_2S, CO, HCN, SO_2, CL_2 sensors; 1 year for NH_3 NO_2 and PH_3 sensors; 6 months for ClO_2, $COCl_2$, and O_3	

Table 7-3.
Measurable Gases, Displays and Resolution

MEASURABLE GASES*	DISPLAY	RESOLUTION	RESPONSE TIME AT 20°C
20 mm SENSORS			
Combustible gases	0 - 100% LEL	1% LEL	t_{50} ≤ 10 s methane ≤ 15 s propane t_{90} ≤ 26 s methane ≤ 35 s propane
O_2	0 - 25 % Vol.	0.1 % Vol.	≤ 10 s
CO	0 - 999 ppm	1 ppm	= 45 s
H_2S	0 - 200 ppm	1 ppm	= 20 s
HCN	0 - 50 ppm	1 ppm	t_{50} < 30 s
Cl_2	0 - 10 ppm	0.1 ppm	t_{50} < 10 s / t_{90} < 30 s
NH_3	0 - 100 ppm	1 ppm	t_{50} < 20 s / t_{90} < 60 s
SO_2	0 - 20 ppm	0.1 ppm	t_{90} ≤ 35 s
NO_2	0 - 20 ppm	0.1 ppm	t_{90} ≤ 25 s
ClO_2	0 - 1 ppm	0.02 ppm	t_{50} < 20 s / t_{90} < 120 s
PH_3	0 - 5 ppm	< 0.05 ppm	t_{90} 30 s
O_3	0 - 1 ppm	0.02 ppm	t_{50} < 30 s / t_{90} < 60 s
$COCl_2$	0 - 1 ppm	0.02 ppm	t_{50} < 60 s / t_{90} < 120 s
IR SENSORS			
HC, Butane	0-25 % Vol.	0.1 % Vol.	
HC, Propane	0-25 % Vol.	0.1 % Vol.	
CH_4, Methane	0-100 % Vol.	1 % Vol.	
C_3H_8, Propane	0-100 % Vol.	1 % Vol.	
C_3H_8, Propane	0-100 % LEL	1 % LEL	
CO_2	0 - 10 % Vol.	0.01 % Vol.	
CO_2	0 - 5 % Vol.	0.01 % Vol.	
CO_2	0 - 50 % Vol.	0.1 % Vol.	

* The gases can only be measured when the appropriate sensors are used.

Table 7-4.
Sensor Cross-Sensitivity

INPUT→ OUTPUT↓	20.9 % Vol O_2	300 ppm CO	20 ppm H_2S	5 % Vol CO_2	33 % LEL CH_4	20 ppm Cl_2	50 ppm NH_3
O_2/ 30 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol
CO/ 300 ppm	0 ppm	300 ppm	0 ppm	0 ppm	0 ppm	2 ppm	23 ppm
H_2S/ 200 ppm	0 ppm	0 ppm	20 ppm	0 ppm	0 ppm	9 ppm	0 ppm
CO_2/ 5% Vol	0 % Vol	0 ppm	0 ppm	5 % Vol	0 ppm	0 ppm	0 ppm
Comb/ 100 LEL	0 LEL	0 LEL	0 LEL	0 LEL	33 % LEL	0 LEL	0 LEL
Cl_2/ 20 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	20 ppm	0 ppm
NH_3/ 100 ppm	0 ppm	0 ppm	2 ppm	0 ppm	0 ppm		50 ppm
SO_2/ 20 ppm	0 ppm	4 ppm	0 ppm Fi (200 ppmh)	0 ppm	0 ppm	-140 ppm*	0.25 ppm
NO_2/ 100 ppm	0 ppm	$\leq$ 0.1 ppm	$\leq$ 40 ppm	0 ppm	0 ppm	200 ppm	$\leq$ 0.25 ppm
PH3/ 5 ppm	0 ppm	1.5 ppm	0 ppm	0 ppm			
ClO_2/ 1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	6 ppm	
O_3/ 1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	24 ppm	-1.5 ppm
HCN/ 50 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm
$COCl_2$/ 1 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	8 ppm	0.15 ppm

* This sensor combination should not be selected.

INPUT → OUTPUT ↓	20 ppm SO_2	100 ppm NO_2	5 ppm PH_3	1 ppm ClO_2	1 ppm O_3	50 ppm HCN	1 ppm $COCl_2$
O_2/ 30% Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol	20.9 % Vol
CO/ 300 ppm	1 ppm	-6 ppm				0.5 ppm	
H_2S/ 200 ppm	0.2 ppm	-7 ppm				0.5 ppm	
CO_2/ 5% Vol	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm	0 ppm
Comb/ 100 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL	0 LEL
Cl_2/ 20 ppm	-2.5 ppm	20 ppm		0.5 ppm	0.12 ppm	-0.5 ppm	
NH_3/ 100 ppm							
SO_2/ 20 ppm	20 ppm	-500 ppm					
NO_2/ 100 ppm	≤ -2.5 ppm	100 ppm					
PH_3/ 5 ppm	4 ppm		5 ppm				
ClO_2/ 1 ppm		37 ppm		1 ppm	0.06 ppm	-2.1 ppm	
O_3/ 1 ppm	-0.2 ppm	60 ppm		1.5 ppm	1 ppm		
HCN/ 50 ppm	0 ppm Fi	-7.3 ppm		-2 ppm	-0.04 ppm	50 ppm	
$COCl_2$/ 1 ppm	0 ppm	10 ppm		-3 pmm	0 ppm	0 ppm Fi	1 ppm

IR X- Sensitivity Table

IR Sensor 0-25 Vol % Methan		
Test Gas	% LEL	% VOL CH4 Display
12.5 Vol % Methane	NA	12.5
Propane	50	25.2
Butane	50	25.8
Nonane	50	26.0
Hexane	50	32.8
Pentan	50	Over Range
Methanol	50	Over Range
Benzene 65/95	50	Over Range
JP8	20	1.5
Ethanol	50	24.3
Toluene	50	2.0
Aceton	50	2.1
Ethylacetat	50	5.6

IR Sensor / 0-100 % LEL Propane		
Test Gas	% LEL	% LEL C3H8 Display
20 Vol % Methane	NA	44.0
Propane	50	50.0
Butane	50	54.0
Nonane	50	48.0
Hexane	50	53.0
Pentan	50	62.0
Methanol	50	61.0
Benzene 65/95	50	66.0
JP8	20	7.0
Ethanol	50	55.0
Toluene	50	13.0
Aceton	50	10.0
Ethylacetat	50	21.0

IR Sensor / 0 - 100 % LEL Butane		
Test Gas	% LEL	% LEL C4H10 Display
20 Vol % Methane	NA	66.0
Propane	50	52.0
Butane	50	50.0
Nonane	50	36.0
Hexane	50	45.0
Pentan	50	55.0
Methanol	50	62.0
Benzene 65/95	50	55.0
JP8	20	6.0
Ethanol	50	55.0
Toluene	50	11.0
Aceton	50	12.0
Ethylacetat	50	27.0

Environment and Oxygen Sensor Readings

A number of environmental factors may affect the oxygen sensor readings, including changes in pressure, humidity and temperature. Pressure and humidity changes affect the amount of oxygen actually present in the atmosphere.

Pressure Changes

The Orion plus oxygen sensor is designed to compensate for ambient pressure changes in the area of instrument operation. If pressure changes rapidly (e.g., stepping through airlock) the oxygen sensor reading may temporarily shift, and possibly cause the detector to go into alarm. While the percentage of oxygen may remain at or near 20.8%, the total amount of oxygen present in the atmosphere available for respiration may become a hazard if the overall pressure is reduced to a significant degree.

Humidity Changes

If humidity changes to any significant degree (e.g., going from a dry, air conditioned environment to outdoor, moisture laden air), oxygen levels can change up to 0.5%. This is due to water vapor in the air displacing oxygen, thus reducing oxygen readings as humidity increases. The oxygen sensor has a special filter to reduce the affects of humidity changes on oxygen readings. This effect will not be noticed immediately, but slowly impacts oxygen readings over several hours.

Temperature Changes

The oxygen sensor has built-in temperature compensation. However, if temperature shifts dramatically, the oxygen sensor reading may shift. Zero the instrument to within 30°C of the temperature-of-use for the least effect.

Chapter 8, Replacement and Accessory Parts

Table 8.1. Accessory Parts List

PART	PART NO.
Protective Jacket, Orange Nylon	10020486
Protective Rubber Boot, Black	10022036
Protective Rubber Boot, Red (North American-approved instrument only)	10025665
Leather Carrying Case	10020485
Calibration Kit Model RP with 0.25 lpm Regulator	477149
Calibration Gas - 100 Liters, 58% LEL pentane simulant / 15% O_2; 300 ppm CO / 2.5% Vol. CO_2	10059149
Calibration Gas - 58 Liters, 58% LEL pentane simulant / 15% O_2; 300 ppm CO and 10 ppm H_2S / 2.5% Vol. CO_2	10050744
Econocal, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O_2/2.5% Vol. CO_2	10058023
Econocal, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O_2/10 ppm H_2S/2.5% Vol. CO_2	10058022
Gas Miser Regulator, Model RP	710288
Regulator, .25 LPM, Model RP	467895
Regulator, Combination, .25 LPM, Model RP	711175
Battery Charger, NiMH, A.C.	10020551
Battery Charger, NiMH, Vehicle	10034276
Battery Pack, NiMH (10031091 Pack with Charging Adapter)	10073663
Battery Pack, Alkaline	10031092
Belt Clip	10025664
Sampling Line, 1.5 m Teflon, PTFE conductive	10074535
Sampling Line 5 m Teflon, PTFE conductive	10021927
Calibration Gas - 58 Liters, 58% LEL pentane simulant / 15% O_2; 300 ppm CO and 10 ppm H_2S	804770
Calibration Gas, 34 Liters, 58% LEL pentane simulant / 300 ppm CO/15% O_2 and 10 ppm H_2S	711058
Calibration Gas, 34L, 300 ppm CO, 1.45% CH_4, 15% O_2, 10 ppm H_2S, 2.5% CO_2, N_2 Balance	10058022
Calibration Gas, 34L, 300 ppm CO, 1.45% CH_4, 15% O_2, 2.5% CO_2, N_2 Balance	10058023
Calibration Gas, 34L, 10 ppm HCN, N_2 Balance	711072
Calibration Gas, 58L, 10 ppm Cl_2, N_2 Balance (to calibrate Cl_2 sensor)	806740
Calibration Gas, 34L, 2 ppm Cl_2, N_2 Balance (to calibrate O_3/$COCl_2$/ClO_2 sensor)	711082
Calibration Gas, 34L, 25 ppm NH_3, N_2 Balance	711078
Calibration Gas, 34L, 10 ppm SO_2, air Balance	711070
Calibration Gas, 34L, 10 ppm NO_2, air Balance	711068

PART	PART NO.
Calibration Gas, 34L, 0.5 ppm PH_3, N_2 Balance	711088
Calibration Gas, 10% CO in N_2	10081603
Calibration Gas, 15% Butane in N_2	10081604
Calibration Gas, 15% Propane in N_2	10081605
Calibration Gas, 58L, 50% Vol Methane, N_2 Balance	10075804
Calibration Gas, 58L, 100% Vol Methane	711014
Calibration Gas, 100L, 0.6% Vol Propane	493579
NiMH Battery with PCBA connector	10073663
Connector, PCBA and nut	10074534
Charger and Cradle	10073666
Upgrade Kit (Cradle, PCBA connector and nut)	10073664
Charging Cradle	10073668
Alkaline Battery pack	10031092
Vehicle Battery Charger	10034276
Assembly Kit for IR Sensor	10080043

Table 8-2. Replacement Parts List

FIGURE 8-1 OR 8-2 ITEM NO.	PART/COMPONENT	PART NO.
1	Pump Cap Assembly, includes screw P/N10025551	10025539
2	Pump Cap Screw	10025551
3	Case Screws	10022921
4	Sensor Cover	10022105
6	Sensor Cover Gasket, Coated	10061454
7	Oxygen Sensor	10025940
8	Toxic Sensor 1	
9	Combustible Sensor	10024247
10	Toxic Sensor 2	
11	Sensor Gasket	10022331
12	Front Case Assembly Keypad	10046364
13	Pump Cap Assembly, includes gasket P/N 10022102	10025539
14	Pump Cap Gasket	10022102
15	Display Assembly	10046366
16	Printed Circuit Board Assembly, Main	10045993
17	IR Sensor	
18	Case Gasket	10022100
19	Pump and Drive Replacement Kit	10031093
21	PTFE filter and Water filter, package of five	10064531

Design & Consultancy for natural and built assets

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Moraine, Ohio

SOP 29 - EXTRACTION STEP TEST

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Everett H. Fortner III, PG Date:

Reviewed by: 03/08/2017

Trika Graham Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

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This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

In a step test, the test well is pumped at several successively higher flow rates (generally 3 to 4) and the drawdown for each flow rate, or step, is recorded in the test well and, if applicable, in nearby observation wells. This testing is used to evaluate the test well specific capacity, establish the test well baseline performance, estimate the test well maximum sustainable yield, and provide an understanding of long-term sustainable flow rate ranges. All steps are generally performed in uniform duration with recovery recorded after the final step.

The initial step flow rate will be approximately half of the expected median flow rate. The understanding of expected flow rate ranges can be determined based on the conceptual site model, analytical calculations, groundwater zone grain size analysis or from the initial test well specific capacity during development. At the conclusion of the first test period (i.e., after approximately 1 hour of pumping with a stable drawdown), the pumping rate is increased based on field observations and estimated maximum or desired maximum yield. The process (steps) are repeated for 3 to 4 cycles, or until a desired maximum flow rate or unsustainable flow rate is established (i.e., the in-well water level rapidly falls, cascades, to the pump intake after the start of pumping). In the case of an unsustainable drawdown that is encountered for the final step flow rate, it may be necessary to draw back the flow rate on the final step to determine the maximum sustained yield. Following the final step, pumping will cease and recovery will be monitored to within 95% of static water level conditions.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Fuel cans
- Generator – with hot fill capability if needed
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow

- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
  - Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
  - Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
  - To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
  - For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
  - For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
  - In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
  - Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
  - Sufficient background water levels should be recorded (approximately 8 to 12 hours).
  - Logarithmic or head-change settings should not be used to log data, only linear.
  - Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.
- Data Recording and Management
  - All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each

reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.

  - Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidently lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).

- Flow Rate
  - Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
  - Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
  - Make sure all equipment that enters the test well (pump, water-level meter, pressure transducer) is decontaminated before use. If testing multiple wells, start with the least contaminated and progress to the most contaminated.
- Weather
  - Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in more cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test well and establish a background monitoring phase. Make sure to record everything in military time.

2. Install pressure transducers for background monitoring phase:
   - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
   - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
   - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
   - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
   - Fill out pressure transducer deployment field log.

3. Set up at the test well pumping system in accordance with the work plan and technical staff. Set up pumping equipment (i.e. downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization). Ensure that a check valve or a ball valve at the top of the well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can be specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. As with all pumping tests, it is critical that the flow rate be held steady. Set the desired flow rate as soon as possible after starting the pump or adjusting (stepping) the flow rate.

4. After at least 8 to 12 hours of background data collection, set to linear logging under non-overwriting recording mode recording at the rate of 1 seconds.

5. Start test, turn pump on, and complete step testing at 3 to 4 flow rates. At least three steps should be performed on each well (typically 33%, 67%, and 100% of anticipated maximum flow rates). However, wells where high yields are expected, a lower maximum flow rate may be determined based on the design flow rate specifications. Each flow rate will be maintained for approximately 1-hour or when stability is apparent before stepping up to the next flow rate. A sustained drawdown (i.e., stable, non-changing) should be observed prior to starting the next test step (i.e., adjusting the flow rate). *Note: A stabilized water level means little or no measurable change over time—use less than 0.03 ft of change over a 10-minutes period as a general guide. This can be monitored in real-time using a laptop connected to the transducer in the pumping test well.*

6. When a step flow rate exceeds the maximum yield (i.e. water-level in the well drops to pump intake), the flow rate will be stepped back incrementally to establish a maximum sustainable flow rate. This may include stepping the flow rate back to the previous step sustained rate. In either case, the final maximum flow rate needs to be maintained for approximately 1-hour before pump is shut off and recovery monitoring commences.

7. Record the manual depth-to-water measurements in the test well with the following sequence (record time along with depth-to-water measurement):
   - every 10 seconds for the first minute,

- every 30 seconds for the next three minutes,
- every minute for the next 15 minutes, and
- every 15 minutes for the remainder of the step.
- Repeat for each step.

8. As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).

9. Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step, and after pump shut off.

10. Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the drawdown before increasing the flow rate. If stabilization is apparent before the 1-hour duration, confirm with technical staff to proceed to next step.

11. After the maximum sustained or end desired design flow rate is achieved and maintained, turn off pump and commence recovery monitoring. Recovery will be monitored to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as described above (again, as time allows, record depth-to-water measurements in the observation wells during the recovery phase of the test).

12. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.

13. Water-IDW. Follow the work plan for water-IDW management, treatment, and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE, and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations, and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust

Moraine, Ohio

SOP 30 - EXTRACTION CONSTANT RATE TEST

Rev #: 0.0

Rev Date: March 8, 2017

APPROVAL SIGNATURES

Prepared by:		03/08/2017
	Everett H. Fortner III, PG	Date:
Reviewed by:		03/08/2017
	Trika Graham	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

A reliable and commonly used method of evaluating aquifer characteristics is by controlled aquifer extraction constant rate tests using a test well and observation wells. Extraction constant rate tests provide results that are more representative of bulk average aquifer characteristics than those predicted by single well tests. Important aquifer characteristics which may be estimated include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers.

In general, an extraction constant rate test is a pumping test set at a constant flow rate completed over longer periods of time (usually 2 to up to 4 days). In addition, data collected within an observation well network can provide data to calculate horizontal and vertical hydraulic gradients that supports the understanding of hydraulic influence.

Proper design of an extraction constant rate test requires a general understanding of the hydrogeologic system so that a suitable work plan can be made. The design incorporates known Site information from the conceptual site model and from any previous hydraulic testing. Factors such as aquifer thickness, level of confinement, step testing, and known permeability range will aid in estimating the duration of the test. Unconfined aquifers will have a longer duration test at 48 to over 72 hours to record late time gravity drainage response. All of this information will aid in the design factors for the work plan such as: number of observation wells, depth and spatial placement of observation wells; duration of background measurements, flow rate(s); frequency of water-level measurements; and duration of the test.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Weather station
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Generator – with hot fill capability if needed

- Fuel cans
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
  - Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
  - Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
  - To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
  - For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
  - For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
  - In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
  - Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
  - Sufficient background water levels should be recorded (at least 3 to 5 days).
  - Logarithmic or head-change settings should not be used to log data, only linear.
  - Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.

- Data Recording and Management
  - All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
  - Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidently lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
  - Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
  - Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
  - Make sure all equipment that enters the test well (pump, water-level meter, pressure transducer) is decontaminated before use. If testing multiple wells, start with the least contaminated and progress to the most contaminated.
- Weather
  - Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in most cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.

- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test well and establish a background monitoring phase. Make sure to record everything in military time.

2. Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).

3. Install pressure transducers for background monitoring phase:
   - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
   - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
   - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
   - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
   - Fill out pressure transducer deployment field log.

4. Set up at the test well pumping system in accordance with the work plan and technical staff. Set up pumping equipment (i.e. downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization). Ensure that a check valve or a ball valve at the top of the well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. As with all pumping tests, it is critical that the flow rate be held steady. Set the desired flow rate as soon as possible after starting the pump.

5. Within the later portion of the background monitoring phase and at least 24 hours before testing, prepare a shakedown of test equipment. A shakedown test is a trial test period to ensure that all equipment is functional and is working within specifications for the main test. The pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade and the protective lid not closed. The shakedown should include the following:
   - Set up generator (hot fill) with grounding rod and GFCI protection
   - Have sufficient fuel containers for fill
   - Verify down-hole test well equipment depth (pump, check and/or top ball valve, and pressure transducer).
   - Verify pressure transducer operation

- Test pump at various flow rates and at the flow rate specified for the test
- Check piping effluent pressure and piping for leaks
- Flow controls (valve operation – always operate pump with some back pressure)
- Flow meter function and manual volume estimate verification
- Check operation of modular treatment system (if applicable)

6. After the shakedown and background monitoring phase is complete, measure water-levels from the specified network and download/re-program the pressure transducers in all wells to start recording (linear – non-overwriting) 2 hours before planned testing start with the below schedule.
   - First 2 hours and then first 30 minutes of testing set at 1 second interval
   - Next 2 hours set at 5 second interval
   - Remainder of test set at 30 second interval

7. Start test, turn on pump, and set flow rate as quickly as possible to be approximate to the design flow rate.

8. Record the manual depth-to-water measurements in the test well with the following sequence (record time along with depth-to-water measurement):
   - every 10 seconds for the first minute,
   - every 30 seconds for the next three minutes,
   - every minute for the next 15 minutes, and
   - every 15 minutes for the remainder of the test.

9. Periodically (every 2 to 4 hours), record manual depth to water measurements from the observation well network during test (record time and depth-to-water measurement).

10. Flow meter readings (instantaneous) should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 30 minutes thereafter. Totalizer flow readings should be recorded before test start and during each instantaneous flow meter recording.

11. If flow rate adjustments are necessary, record each on the field form. However, the flow rate should be maintained as close as possible to the start for the duration of the test.

12. Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the drawdown and late time aquifer response. Unconfined aquifer systems require longer duration of pumping to record the aquifer gravity drainage response. Duration should be maintained and stabilization apparent before shutting down the test. Confirm with technical staff to proceed with shut down after all responses have been verified.

13. After the testing response has been verified, shut down the pump and monitor recovery to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as during the start of the test.

14. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.

15. Water-IDW. Follow the work plan for water-IDW management, treatment and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust

Moraine, Ohio

SOP 31 – Injection Step Testing for DGR™ Systems

Rev #: 0.0

Rev Date: March 14, 2017

APPROVAL SIGNATURES

Prepared by:		03/14/2017
	Everett H. Fortner III, PG	Date:
Reviewed by:		03/14/2017
	Peng, Jin, PhD, PE	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

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2 SCOPE AND APPLICATION

The approach to an injection step test for dynamic groundwater recirculation (DGR™) systems is to evaluate injection flow rate well capacity (under gravity fed conditions – no applied pressure) using successively higher flow rates (generally 3 to 4). This testing is used to establish the test well injection baseline performance, estimate the test well maximum injection flow rate, and provide an understanding of long-term sustainable injection flow rate ranges. All steps are generally performed in uniform duration with recovery recorded after the final step. Large-volume injection testing may still be necessary to confirm full-scale injection rates. This information aids in design of the recirculation test and full-scale DGR™ design elements.

The understanding of expected flow rate ranges can be determined based on the conceptual site model, analytical calculations, groundwater zone grain size analysis, or from the initial test well extraction tests. The initial injection step flow rate can be estimated by using 25% to 33% of the maximum sustainable extraction flow rate of the test well. The duration of each step is expected to be 1 hour; however, both duration and subsequent injection step flow rates will be adaptive based on initial step results. The injections will be completed by pumping stored, treated water within piping to a manifold at the well head. Flow rate and well head pressure at the manifold will be closely monitored and recorded.

The response of in-well water-levels (both test well and observation wells) should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter, if accessible. Flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements. Following the final step, injection will cease and recovery will be monitored to within 95% of static water level conditions.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient "hands-on" experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Injection manifold, piping, pressure gauges, flow meter, and transfer injection pump
- Buckets, drums, and tanks
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for injection test and decon
- Field forms
- Waterproof marker
- Tools
- Digital camera
- PPE
- Generator – with hot fill capability if needed
- Fuel cans
- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed

5 CAUTIONS

- Pressure Transducers/Data Loggers
    - Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
    - Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the static water level (approximately 15 feet).
    - To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
    - For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
    - For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
    - In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
    - Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
    - Sufficient background water levels should be recorded (at least 8 to 12 hours).
    - Logarithmic or head-change settings should not be used to log data, only linear.
    - Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.
- Data Recording and Management
    - All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
    - Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. Always back up data on a laptop computer and/or a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
    - Flow meters should come with calibration certificate and confirmed in the field during test start up.

- Equipment Care
  - Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination
  - Make sure all equipment that enters the test wells (water-level meter, pressure transducer) is decontaminated before use.
- Weather
  - Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in more cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

- Measure water-levels and total well depth in all applicable observation wells and test wells and establish a background monitoring phase. Make sure to record everything in military time.
- Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).
- Install pressure transducers for background monitoring phase:
  - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
  - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.

  - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
  - The pressure transducer will be attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
  - Fill out pressure transducer deployment field log.
- Set up injection equipment in accordance with work plan and technical staff direction (i.e. injection pump, manifold, downhole test well equipment, piping, and flow meters).
- After at least 8 to 12 hours of background data collection, reprogram pressure transducers to linear logging under non-overwriting recording mode recording at the rate of 1 seconds.
- Start test, turn on injection well pump and complete step testing at 3 to 4 flow rates. At least three steps should be performed on each well and maintained for approximately 1-hour or when stability is apparent before stepping up to the next flow rate. A sustained rise in water-level (i.e., stable, non-changing) should be observed prior to starting the next test step (i.e., adjusting the flow rate). Note: A stabilized water level means little or no measurable change over time—use less than 0.03 ft of change over a 10-minute period as a general guide. This can be monitored in real-time using a laptop connected to the transducer in the test well.
- As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).
- Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step, and after pump shut off.
- If flow rate adjustments are necessary, record each on the field form. However, the flow rates for the injection should be maintained as close as possible to the start for the duration of the test.
- As time allows, periodically record manual depth to water measurements from the observation well network during each step (record time and depth-to-water measurement).
- Flow meter readings should be recorded once every minute for the first 10 minutes. Continued recording of the flow meter should be recorded on the field form every 5 minutes thereafter. Totalizer flow readings should be recorded before test start, before each step and after pump shut off.
- Data evaluation will be real time. A plot from the direct read transducer of the test well pressure transducer will be evaluated during the test to ensure stabilization of the water-level rise before increasing the flow rate. If stabilization is apparent before the 1-hour duration, confirm with technical staff to proceed to next step.
- After the maximum sustained or end desired design injection flow rate is achieved and maintained, turn off pump and commence recovery monitoring. Recovery will be monitored to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as described above (again, as time allows, record depth-to-water measurements in the observation wells during the recovery phase of the test).

- Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.
- Water-IDW. Follow the work plan for water-IDW management, treatment and discharge

8 WASTE MANAGEMENT

Rinse water, PPE, and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None

RACER Trust

Moraine, Ohio

SOP 32 - RECIRCULATION TEST FOR DGR™SYSTEMS

Rev #: 0.0

Rev Date: March 14, 2017

APPROVAL SIGNATURES

Prepared by: ______________________ 03/14/2017

Everett Fortner III, PG — Date:

Reviewed by: ______________________ 03/14/2017

Jonathon Roller, PG — Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The approach to a recirculation test for dynamic groundwater recirculation (DGR™) systems is to collect observed response to injection balanced by extraction using a single injection well and a single extraction well, along with observation wells. The observed responses will provide information on changes in horizontal and vertical hydraulic gradients and evaluate hydraulic connection between the injection and extraction well. This information aids in full-scale DGR™ design elements.

Proper design of a recirculation test requires a general understanding of the hydrogeologic system so that a suitable work plan can be made. The design incorporates known Site information from the conceptual site model and from any previous testing that includes extraction and injection testing. All of this information will aid in the design factors for the work plan such as: number of observation wells, depth and spatial placement of observation wells; duration of background measurements, injection/extraction flow rate(s); frequency of water-level measurements; and duration of the test.

Extraction and injection step testing should preclude a recirculation test in order to properly design the flow rates for injection and extraction.

The response of in-well water-levels (both test well and observation wells) to pumping should be recorded with pressure transducer/data loggers and also manually measured with an electronic water-level meter. Injection and extraction flow rates should be maintained steady and recorded in detail with total flow and instantaneous measurements.

3 PERSONNEL QUALIFICATIONS

Field personnel performing the testing will have the following qualifications:

- Familiarity and competency with quantitative hydrogeology, understanding of the Site, this SOP, and the work scope.
- Sufficient “hands-on” experience necessary to successfully complete the field work.
- Demonstrated familiarity with equipment such as injection equipment, submersible pumps, flow meters, and electronic data logging equipment.
- Completed current health and safety training in accordance with the project health and safety plan (e.g., 40-hour Hazardous Waste Operations training and site-specific training, as appropriate).

4 EQUIPMENT LIST

- Water level meter(s) – calibrated if using multiple
- Pressure transducer(s) – appropriate for water column range and data logging capabilities (e.g. Solinst AquaVent with direct read cable for the test well, Solinst Level Logger Edge for observation wells)
- Barometric pressure logger (e.g. Solinst barologger)
- Weather station
- Pressure transducer communication equipment, manuals, and calibration certificates
- Laptop computer or other interface for pressure transducers
- Variable speed submersible pump capable of test design flow rates with flow controller
- Valves for effluent piping run
- Injection manifold, piping, pressure gauges, flow meter, and transfer injection pump
- Check-valve (i.e., back-flow preventer) for submersible pump
- Buckets or drums
- IDW containerization (if necessary) and proper labeling
- Approved decon detergent
- Potable water for decon
- Fluorescein dye, sample bottles, visual dye standards, and AquaFluor Handheld Fluorometer
- Graduated cylinders (50 mL and 1L)
- Scale to measure weight of dye to the nearest 1 gram
- Field forms
- Waterproof marker
- Low-flow submersible pump, controller, and tubing (for observation well dye verification)
- Tools
- Digital camera
- PPE
- Measuring wheel
- Tripod, winch, and suspension cable
- Generator – with hot fill capability if needed
- Fuel cans

- In line flow meter(s) – totalizer or combination totalizer and instantaneous flow
- Shelter, table, and chairs, if needed
- Modular treatment system – if applicable

5 CAUTIONS

- Pressure Transducers/Data Loggers
  - Ensure all rental instruments and water-level tapes are in good working order and have calibration documentation, if applicable.
  - Small-diameter pressure transducers (typically 0.5 to 0.75 in) are available that could cover a range of pressures. Install the pressure transducer at a reasonable distance below the pump intake to prevent noise (over 1 foot).
  - To prevent pressure transducer malfunction or damage, do not submerge pressure transducers in excess of the operating range and do not insert objects in the sensor opening.
  - For vented pressure transducers/data loggers, test functionality with a field test of readings using a bucket or barrel filled with water. Submerge pressure transducer, accurately measure the water head above the pressure transducer, and compare the measurement to the reading.
  - For non-vented transducers, which record a combined pressure of barometric and the water column above the pressure transducer, can be tested in the same fashion as the vented pressure transducer (outlined above). The water column above the pressure transducer can be checked by subtracting out current atmospheric pressure.
  - In general, when testing the pressure transducers, check the pressure transducer response to changing heads by raising the pressure transducer a certain distance, observing the change in head, and then measuring the distance manually. Additionally, water level meters should be in good working condition and calibrated to true depth and ensuring there are no breaks or splices in the cable.
  - Pressure transducers should be set in the well at least 20 minutes prior to recording start to allow to the transducer to thermally equilibrate with groundwater and ensure that the pressure transducer cable will not stretch. This initial period is for instrument equilibration only and does not include background monitoring.
  - Sufficient background water levels should be recorded (at least 12 to 24 hours).
  - Logarithmic or head-change settings should not be used to log data, only linear.
  - Prior to testing, secure pressure transducer cables at the wellhead to prevent movement that would affect measurements. Mark a reference point on the down-hole transducer cable or securing line and check regularly to detect slippage. Use manufacturer supplied well head caps if available. For larger diameter wells, loop the cable and use tape to secure cable to well outer casing.

- Data Recording and Management
  - All watches and other time-measurement devices (i.e., laptop computer and pressure transducers) should be synchronized so that the time (using 24-hour military format) of each reading, electronic and manual, can be referenced to the exact minute and hour that pumping started.
  - Data management is crucial to prevent any loss. Use caution not to overwrite any previously recorded files and remember, data backup is always necessary. A job loss would occur if data would be accidently lost. Always back up data on a laptop computer and a flash drive and keep at different spots (e.g., back pack and glove compartment) to reduce the risk of data loss (e.g., computer failure).
- Flow Rate
  - Flow meters should come with calibration certificate and confirmed in the field during test start up.
- Equipment Care
  - Keep sensitive electronic equipment away from devices that generate significant magnetic fields. For example, do not place pressure transducers near electric power generators or electric pump motors. Likewise, radio signals may cause pressure transducers or computers to malfunction.
- Decontamination (see SOP X)
  - Make sure all equipment that enters the test wells (pump, water-level meter, pressure transducer) is decontaminated before use.
- Weather
  - Ensure that heavy rainfall has not occurred within 48 hours and is not expected during testing. Recharge causes influence to water levels that in most cases can't be corrected and would cause anomalous results. If weather conditions are questionable, check with technical staff for direction.

6 HEALTH AND SAFETY CONSIDERATIONS

The site-specific HASP will be used to ensure that the tests are conducted in a safe manner, and will include appropriate Job Safety Analyses (JSAs). The following specific health and safety issues will be considered when conducting pumping tests:

- Appropriate PPE with minimum of Level D must be worn to avoid contact with site chemicals of concern during slug test.
- Well covers must be carefully removed to avoid potential contact with insects or animals. Well caps should be vented or tethered to avoid potential eye injury in case of gas buildup in the well.
- Pressurization or vacuum hazards associated with pipes and fittings should be considered during test planning and implementation.
- Downhole equipment assemblages (pump and piping) may be too heavy for hand deployment and may require the use of a tripod, winch or crane truck.

7 PROCEDURE

1. Measure water-levels and total well depth in all applicable observation wells and test wells and establish a background monitoring phase. Make sure to record everything in military time.

2. Install tipping bucket (rain gauge), tipping bucket data logger, and barometric pressure logger (note that the programming of the barologger should match the well pressure transducer schedule for background and testing).

3. Install pressure transducers for background monitoring phase (12 to 24 hours):
   - Pressure transducers in observation wells will be attached using a direct read communication cable or Kevlar cord.
   - The background data acquisition will be set to linear logging under non-overwriting recording mode recording at the rate of 30 seconds.
   - The pressure transducers will be set at 15 feet below the water table or 6 inches above the total depth of the well (if limited water column is available).
   - The pressure transducer will be set in the test well approximately 1 to 3 feet below the pump housing attached with a direct read cable for real time monitoring with a laptop or similar interface. Specifically, the pressure transducer cable will be attached to solid surface mount with wire ties or something similar.
   - Fill out pressure transducer deployment field log.

4. Set up injection and pumping equipment (i.e. injection manifold, downhole test well equipment, piping, flow meters, modular treatment, and IDW containerization [if applicable]). Ensure that a check valve or a ball valve at the top of the extraction test well head is installed to limit drainage of the effluent line after pump shutdown. If a ball valve is used, the valve will need to be shut precisely after pump shut off. The extraction pump intake should be above the top of the well screen if the water column and expected drawdown permits. Note that the flow meter and other sensitive equipment should be protected as best as possible from the elements under a temporary shelter. The pump controller can be specifically sensitive to humidity and overheating with exposure to direct sunlight. Ensure that the controller is well ventilated, in the shade, and the protective lid not closed. It is critical that the flow rates be held steady as best as possible for both injection and extraction. Set the desired flow rate as soon as possible after starting the pump.

5. Within the later portion of the background monitoring phase and at least 24 hours before testing, prepare a shakedown of test equipment. A shakedown test is a trial test period to ensure that all equipment is functional and is working within specifications for the main test. The shakedown should include the following:
   - Set up generator (hot fill) with grounding rod and GFCI protection
   - Have sufficient fuel containers for fill
   - Verify down-hole extraction test well equipment depth (pump, check and/or top ball valve, and pressure transducer).
   - Verify pressure transducer operation
   - Verify injection manifold and transfer pump set up
   - Test injection transfer pump at various flow rates and at the flow rate specified for the test (use water with no dye applied for shakedown)
   - Test pump at various flow rates and at the flow rate specified for the test
   - Check piping pressures and check for any leaks
   - Flow controls (valve operation – always operate pump with some back pressure)
   - Flow meters function and manual volume estimate verification
   - Check operation of modular treatment system (if applicable)

6. After the shakedown and background monitoring phase is complete, measure water-levels from the specified network and download/re-program the pressure transducers in all wells to start recording (linear – non-overwriting) 2 hours before planned testing start with the below schedule.
   - First 2 hours and then first 30 minutes of testing set at 1 second interval
   - Next 2 hours set at 5 second interval
   - Remainder of test set at 30 second interval

7. Prepare injection water (treated or potable) with fluorescein dye concentration at 40 ppm. The dye will be used to help with qualitative visual confirmation of recirculation.
   - Prior to drilling, measure the proper weight of powdered dye for mixing with injection water – 75 grams of fluorescein dye will be added to every 500 gallons of water to yield on average tracer concentration of approximately 40 ppm.
   - If the injection water "batch" is larger or smaller than 500 gallons, the same ratio of dye to water will be used.
   - Measure the mass of the dye using a scale with an accuracy of +/- 1 gram.
   - Add the dye to the injection water batch tank(s) while using a utility pump to mix the tracer with the injection water.
   - Collect four 40 mL unpreserved VOA vials from each tank of injection water – label all four of these vials "W-1" for the first batch of injection water, "W-2" for the second batch, etc.
     - Photograph the "W" samples from each batch of injection water with adequate, consistent light, against a white background.
     - Keep all of the dyed injection water ("W") samples in a cooler to keep them dark, to inhibit photodegradation.
   - The pH injection water source should be measured. A pH value below approximately 5 standard units results in reduced fluorescence of the fluorescein.

8. Start the test by turning on the extraction well pump and injection well transfer pump simultaneously and set flow rates as quickly as possible to be approximate to the test design flow rates.

9. Record the manual depth-to-water measurements in the extraction test well with the following sequence (record time along with depth-to-water measurement):
   - every 10 seconds for the first minute,
   - every 30 seconds for the next three minutes,
   - every minute for the next 15 minutes, and
   - every 15 minutes for the remainder of the test.

10. Periodically (every 2 to 4 hours) record manual depth to water measurements from the observation well network during test (record time and depth-to-water measurement).

11. Flow meter readings (instantaneous) should be recorded once every minute for the first 10 minutes. Continued recording flow rates from the flow meters documented on the field form every 30 minutes thereafter. Totalizer flow readings should be recorded before test start and during each instantaneous flow meter recording.

12. If flow rate adjustments are necessary, record each on the field form. However, the flow rates for the injection and extraction should be maintained as close as possible to the start for the duration of the test.

13. Set up low-flow sampling pump into specified observation well(s) at mid-screen. Set flow rate to a flow rate between 300 to 800 mL per minute. Collect groundwater samples in 40 mL unpreserved VOA vials every 30 minutes from the designated observation well(s) and extraction test well to

verify presence of tracer dye. If present, use field fluorometer to measure dye concentration and save samples in cooler on ice and label with well ID, date, and time.

14. Data evaluation will be real time. A plot from the direct read pressure transducer of the test wells will be evaluated during the test to ensure stabilization. Maximum duration of the test will be determined by the technical staff and may be up to 24 hours.

15. After the testing response has been verified, shut down the pumps and monitor recovery to at least 95% or greater of the pre-test conditions. Manual depth-to-water measurement frequencies will be the same as during the start of the test.

16. Final depth to water measurements will be taken from the observation wells and test well before pulling any equipment (pumps or transducers). The pressure transducers then can be downloaded and the data maintained on two separate devices (CPU and flash drive) to ensure no data loss.

17. Water-IDW. Follow the work plan for water-IDW management, treatment and discharge.

8 WASTE MANAGEMENT

Rinse water, PPE and other waste materials generated during equipment decontamination will be placed in appropriate containers and labeled in accordance with Arcadis' TGI on IDW. Containerized waste will be disposed of, consistent with appropriate waste management procedures for investigation-derived waste.

Containerize all purged water as specified in the work plan. Discharge water must be disposed of according to all applicable laws, regulations and project guidelines. Contact the governing agencies to determine which restrictions apply. Arcadis should not "take possession" of purged water.

9 DATA RECORDING AND MANAGEMENT

Field personnel will complete all applicable field forms for each test. Forms should include recommended data file naming protocol. It is recommended that data be copied to a flash drive and transmitted along with field notes to the project team as soon as possible to ensure no data loss. Field equipment calibration, decontamination activities, and waste management activities will be recorded in the field notebook or daily log.

10 QUALITY ASSURANCE

Review data collected during field testing to determine reasonableness/quality given documented site-specific conditions. Again, this can also be completed using the pressure transducer in real-time viewing mode as the test progresses. If the data are questionable, the field equipment must be checked to confirm proper working order and the test may be repeated, if possible. Consult with the technical staff to work through issues encountered in the field and to help determine test validity.

Any issues that may affect the data must be recorded in the field notebook or daily log for consideration by the technical staff. Follow data file naming protocol and other information needed on applicable field forms.

11 REFERENCES

None.

APPENDIX C

Field Forms

DAILY LOG

Project No.: ______________________________ Page ______ of ______

Site Location: ______________________________

Prepared By: ______________________________

Date	Time	Description of Activities

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GROUNDWATER SAMPLING LOG

Page ____ of ____

Project No. ______________ Well ID ______________ Date ______________

Project Name/Location ______________ Weather ______________

Measuring Pt. Description ______________ Screen Setting (ft-bmp) ______________ Casing Diameter (in.) ______________ Well Material ____ PVC ____ SS

Static Water Level (ft-bmp) ______________ Total Depth (ft-bmp) ______________ Water Column/ Gallons in Well ______________

MP Elevation ______________ Pump Intake (ft-bmp) ______________ Purge Method: ______________ Sample Method ______________

Centrifugal ______________

Submersible ______________

Pump On/Off ______________ Volumes Purged ______________ Other ______________

Sample Time: Label ______ Start ______ End ______

Replicate/ Code No. ______________

Sampled by ______________

Time	Minutes Elapsed	Rate (gpm) (mL/min)	Depth to Water (ft)	Gallons Purged	pH	Cond. (mMhos) (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (^oC) (^oF)	Redox (mV)	Appearance	
											Color	Odor

Constituents Sampled	**Container**	**Number**	**Preservative**

Well Casing Volumes

Gallons/Foot					
	1" = 0.04	1.5" = 0.09	2.5" = 0.26	3.5" = 0.50	6" = 1.47
	1.25" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65	

Well Information

Well Location:		Well Locked at Arrival:	Yes / No
Condition of Well:		Well Locked at Departure:	Yes / No
Well Completion:	Flush Mount / Stick Up	Key Number To Well:	

SOIL BORING LOG

Boring No.:

Sheet : 1 of

Project Name: ____________ Date Started: ____________ Logger: ____________

Project Number: ____________ Date Completed: ____________ Editor: ____________

Project Location: ____________ Weather Conditions: ____________

Depth (feet)	Blow Counts	Sample ID & Time	Recovery (in.)	PID (ppm)	USCS Class.	Description	Construction Details
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Drilling Co.: ____________ Sampling Method: ____________

Driller: ____________ Sampling Interval: ____________

Drilling Method: ____________ Water Level Start: ____________

Drilling Fluid: ____________ Water Level Finish: ____________

Remarks: ____________ Converted to Well: ☐ Yes ☐ No

Surface Elev: ____________

North Coor: ____________

East Coor: ____________

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SOIL/SEDIMENT/SLUDGE SAMPLING LOG

Project/ Site Location ______________________ Date ____________

Project No. ____________

Sample No. ______________________ Coded Replicate No. ____________

Time Sampling Began ______________________ Time Sampling Ended ____________

Sampling Method and Material: ______________________

____

From	To	Soil/Sediment/Sludge Description

OTHER (OVA; HNu; etc.) ______________________

____

Constituents Sampled	Container Description	Preservative

Remarks ______________________

____

____

Sample Personnel ______________________

ARCADIS

Slug Test Log

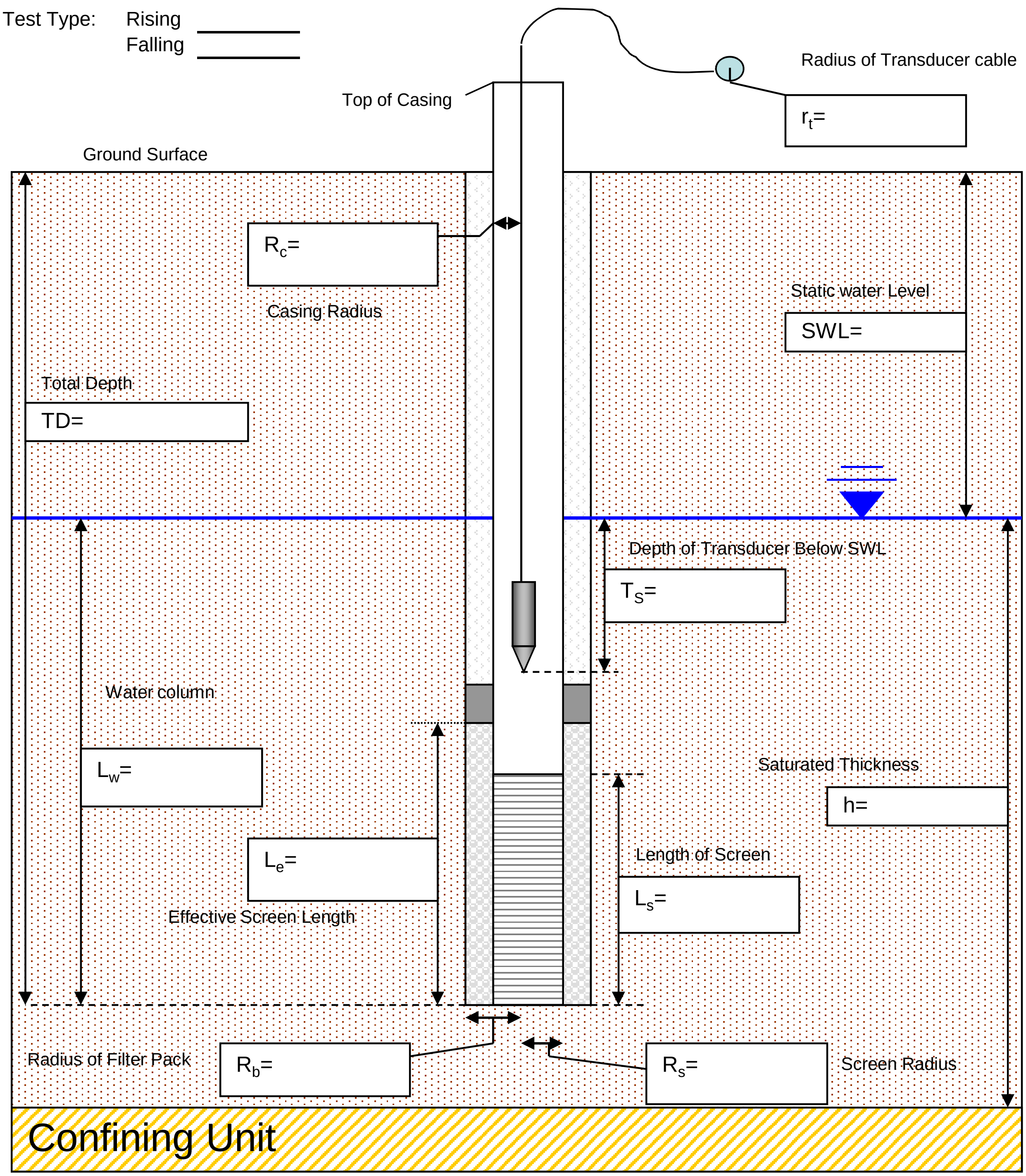
Site Name: ______________________ Project No: ______________________ Page: ____ of ____

Well No: ______________ Prepared By: ______________________ Date: ______________ Time: __________

Completed By: ______________________

Test Type: Rising ________

Falling ________



ARCADIS

Slug Test Log

Site Name: ______________________ Project No: ______________ Page: ___ of ___

TESTS

Number of Tests: ________ Data File Name: ________________ Data File Location: ____________________

Input Pressure: ________ Pressure Transducer SN: ____________ r_t: _____

Test ID: T_S Baseline: __________ Pressure Reading: ____________

__________ H_o: __________ Test Start ______ Test End ________

Test ID: T_S Baseline: __________ Pressure Reading: ____________

__________ H_o: __________ Test Start ______ Test End ________

Test ID: T_S Baseline: __________ Pressure Reading: ____________

__________ H_o: __________ Test Start ______ Test End ________

Notes:

H_o	Initial change in head at instant the slug test is started
r_t	Radius of transducer cable
T_S	Depth of transducer below static water level

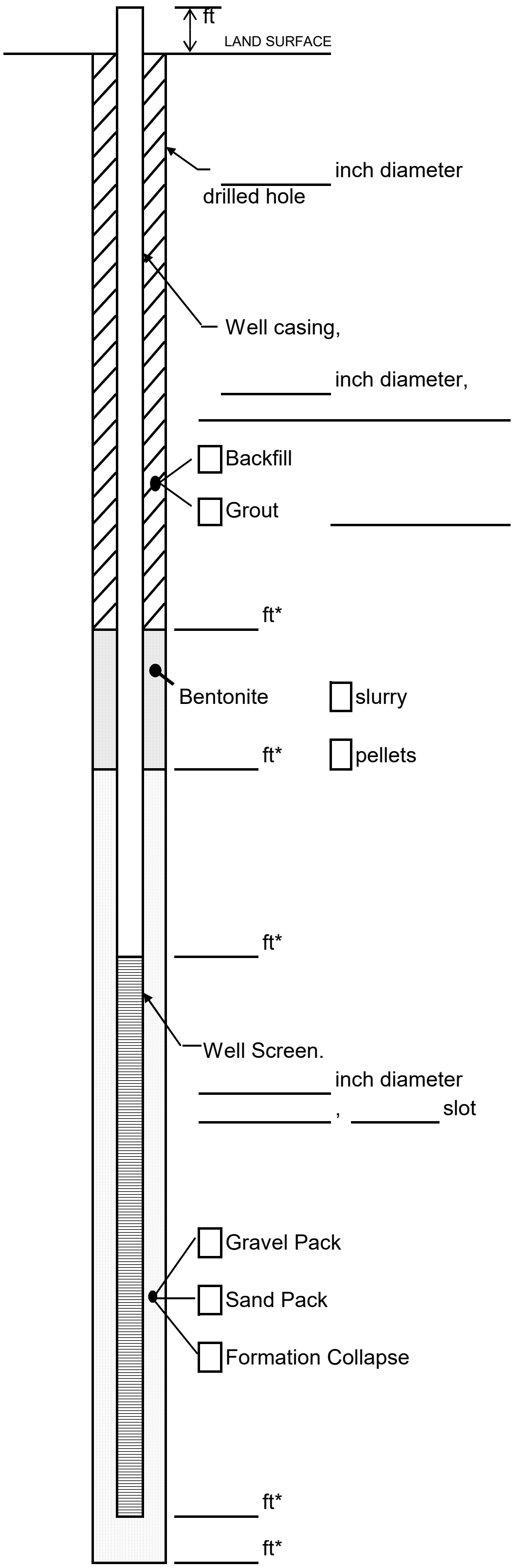
Theoretical Change in Head - 2.307 feet = 1 psi

(Feet)	**(psi)**	**(Feet)**	**(psi)**	**(Feet)**	**(psi)**
0.50	**0.22**	**1.50**	**0.65**	**2.50**	**1.08**
0.75	**0.33**	**1.75**	**0.76**	**2.75**	**1.19**
1.00	**0.43**	**2.00**	**0.87**	**3.00**	**1.30**
1.25	**0.54**	**2.25**	**0.98**	**3.25**	**1.41**

Well Parameters Required for Calculating Hydraulic Conductivity

L_e	Effective screen length, including the sand pack
L_s	True screen length
L_w	Length of water column in Well (TD-SWL)
R_s	Screen radius
R_b	Radius of filter Pack or borehole
R_c	Casing radius
r_t	Radius of the transducer cable
T_s	Depth the transducer is submerged below the SWL
SWL	Static water level
TD	Total depth of well/screen from reference point
h	Saturated thickness of aquifer
H_o	Initial head change at instant the slug test is started.
Aquifer Type	Confined or unconfined

WELL CONSTRUCTION LOG
(Unconsolidated)



Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project ____________________ Well ________

Town/City ____________________

County ____________________ State ________

Permit No. ____________________

Land-Surface (LS) Elevation and Datum:

____________________ feet ☐ Surveyed

☐ Estimated

Installation Date(s) ____________________

Drilling Method ____________________

Drilling Contractor ____________________

Drilling Fluid ____________________

Development Technique(s) and Date(s)

Fluid Loss During Drilling ____________ gallons

Water Removed During Development ______ gallons

Static Depth to Water ____________ feet below M.P.

Pumping Depth to Water ____________ feet below M.P.

Pumping Duration ________ hours

Yield ________ gpm Date ________

Specific Capacity ________ gpm/ft

Well Purpose ____________________

Remarks ____________________

Prepared by ____________________

ARCADIS

ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:		
	Contact & Company Name:	Telephone:
	Address:	Fax:
	City State Zip	E-mail Address:

Project Name/Location (City, State):	Project #:
Sampler's Printed Name:	Sampler's Signature:

Preservative							
Filtered (✓)							
# of Containers							
Container Information							

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil SE - Sediment NL - NAPL/Oil
W - Water SL - Sludge SW - Sample Wipe
T - Tissue A - Air Other: _______

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix								REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: _________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

Distribution: **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by Arcadis**

CHAIN-OF-CUSTODY SEAL • CHAIN-OF-CUSTODY SEAL

ARCADIS

CHAIN-OF-CUSTODY SEAL • CHAIN-OF-CUSTODY SEAL

Sample Label

ARCADIS	SAMPLE I.D.	
PROJECT #		DATE
SAMPLE TYPE ❑ Soil/Sediment ❑ Water	COLLECTION MODE ❑ Composite ❑ Grab	TIME
ANALYSIS		
SAMPLER	PRESERVATIVE	

INJECTION TEST FIELD LOG

Date: ______________________ Test Area: ______________________

Weather: ______________________ Injection Well/Zone: ______________________

Site: ______________________ Personnel: ______________________

INJECTION SOLUTION CHARACTERISTICS

	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6
Volume of Water (gal):						
Volume of EVO (gal):						
Volume of Rhodamine WT (mL):						

INJECTION LINE READINGS

Time (24HR)	Wellhead Pressure (psi)	Totalizer Volume (gal)	Flowrate (gal/min)	Tank Volume (gal)	Cumulative Volume (gal)	Notes (gravity feed / pressurized, etc.)

MANUAL WATER LEVEL RECORD, FOR PUMPING TEST

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MEASUREMENTS IN OBSERVATION WELL #: ____________________ Sheet: ___ of ___

Job Name: ____________________ Location: ____________________

Well Diameter: __________ Pumped Well: ____________________ Step No. ____________________

Measure Point: __________ Distance from Pumped Well: __________ Start Date: ____________________

Average Flow: ____________________

Depths Below Measuring Point (feet)														
Static Level	Well Bottom	Screen Top	Screen Base	Transducer				**Static Water Level:**		Static Time:				
Date	Time (24 hr Clock)	Elapsed Time (mins)	Depth to Water (ft)	Drawdown (ft)	Date	Time (24 hr Clock)	Elapsed Time (mins)	Depth to Water (ft)	Drawdown (ft)	Date	Time (24 hr Clock)	Elapsed Time (mins)	Depth to Water (ft)	Drawdown (ft)

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PUMPING/RECOVERY TEST LOG

PROJECT ____________________ **WELL** __________ **SITE LOCATION** ____________________

PERSONNEL ____________________ **PM/TM** ____________________

Well construction

measuring point description: __________

sounded depth to bottom (ft bMP): __________

screened interval (ft bgs): __________

casing diameter (cm): __________

SWL and pump deployment

static DTW (prior to pump insertion): __________

static DTW (after pump insertion): __________

approx. pump depth (intake, ft btoc) __________

Pump type: __________

Test Details Date: __________

Time pumping started: __________

target rate (gpm) __________

Time pumping stopped: __________

Total pumping duration (min): __________

total volume removed (gal) __________ Time pumping stopped __________ total duration (min) __________

calculated rate, from totalizer (gpm) __________

Notes: ____________________

Date	TIME (24 hour)	ELASPED TIME (calculate) (min)	DEPTH TO WATER (ft btoc)	Measured flow rate (gpm)	Totalizer reading (gal)	Notes (begin pumping, rate change, stop pumping, etc.)
		pre-test static:		--		

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Date	TIME (actual)	ELASPED TIME (calculate) (min)	DEPTH TO WATER (ft btoc)	Measured flow rate (gpm)	Totalizer reading (gal)	**Notes** (begin pumping, rate change, stop pumping, etc.)

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Injection/Tracer Test Solution Mixing Summary

Target EVO Strength, by Volume	--	2.5%
Target Rhodamine WT Concentration	ppm	40

Solultion Type	Component	unit	Quantities per Batch								
	Solution Volume	(gal)	100	150	200	250	300	350	400	450	500
EVO and Tracer	EVO	(gal)	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5
	Rhodamine WT	(mL)	15	23	30	38	45	53	61	68	76
EVO Only	EVO	(gal)	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5

Note:
gal - gallon
mL - milliliter
ppm - part per million