Infrastructure · Water · Environment · Buildings

ARCADIS of New York, Inc.
6723 Towpath Road
PO Box 66
Syracuse
New York 13214-0066
Tel 315 446 9120
Fax 315 449 4111
www.arcadis-us.com

Mr. William Ports
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 11th Floor
Albany, New York 12233-7014

ENVIRONMENT

Subject:
OU-1 Petroleum LNAPL Assessment Work Plan
NYSEG Cortland-Homer Former MGP Site
Homer, New York
NYSDEC Site # 7-12-005

Date:
June 6, 2013

Contact:
John C. Brussel, PE

Phone:
315 671 9441

Email:
John.Brussel@arcadis-us.com

Our ref:
B0013123.0004 #8

Dear Mr. Ports:

This letter presents a work plan for assessing the nature, extent and recoverability of petroleum-based light non-aqueous phase liquid (LNAPL) observed at the New York State Electric & Gas Corporation (NYSEG) Cortland-Homer former manufactured gas plant (MGP) site located in Homer, New York. This work plan also describes repairs to be made to several monitoring wells that were damaged or lost during the recent in-situ soil solidification (ISS) remedial construction project.

Background

ARCADIS prepared this work plan in response to the discovery of LNAPL within the southern portion of Operable Unit 1 (OU-1) during the ISS project. LNAPL was measured (0.2 foot thickness) and removed in February 2013 from monitoring well MW-11, located at the southeast corner of OU-1 (see Figure 1). The data for the February 2013 water/LNAPL gauging activities are shown in Table 1. Subsequent monitoring during final ISS remedial construction did not identify measurable LNAPL. However, the water table may have been elevated above the screened interval at the time monitoring was completed. Also, indications of LNAPL were observed in several test pits excavated in the general area south of the OU-1 ISS monolith. Extensive excavation completed along the utility corridor that parallels US Route 11, completed to access the municipal water main, provided an opportunity to observe the subsurface east of the area where LNAPL was observed. LNAPL was not observed at the water table in that excavation, suggesting limited LNAPL extent. The suspected source of the LNAPL is a former oil tank that was located in the southwest corner of the site (see Figure 1).

The main objective of the work described in this letter is to assess the nature, extent, and recoverability of petroleum LNAPL in the subsurface south of the OU-1 ISS monolith. A secondary objective is to repair or replace monitoring wells damaged or lost during the remedial activities to restore the network of monitoring wells at and near the site.

A discussion of the proposed work activities is provided below.

Monitoring Well Installation

Four new groundwater monitoring wells (MW-31 through MW-34, as shown on Figure 1) will be installed in the area south and east of OU-1, as described below:

- Three 4-inch diameter wells along the eastern and southern property boundaries (around existing monitoring well MW-11) to create a "curtain" of wells hydraulically downgradient from the area where petroleum LNAPL has been identified.

- One 4-inch diameter well on the grocery store property (former Natoli's Market) south of the site, as a replacement to monitoring well MW-29S. The replacement well (MW-34) will be installed only if an obstruction in MW-29S (a bailer currently silted-in-place) cannot be removed and the well cannot be restored to a useful condition. If the bailer is removed from MW-29S, the well will be redeveloped.

Prior to drilling, the uppermost five feet of the boring at each proposed well location will be advanced using vacuum boring or hand methods to avoid subsurface utilities.

Borings will be drilled to a depth of approximately 20 feet bgs using conventional 6¼-inch hollow-stem auger (HSA) drilling and sampling techniques. Soil samples will be continuously collected from each boring using a 2-inch outside diameter split-spoon sampler and will be visually characterized for color, texture, and moisture content. Any observations noted for the sample, including the presence of discoloration, oily residue, or obvious odors, will be recorded. A portion of the soil from each 2-foot interval will be screened for volatile vapors using a photoionization detector (PID).

Each proposed monitoring well will be constructed of 4-inch-diameter Schedule 40 polyvinyl chloride (PVC) pipe with a 10-foot-long, 0.020-inch slotted screen. The top of the screen will be positioned approximately two-to-three feet above the highest water table as observed between June 2012 (i.e., the pre-remediation baseline groundwater monitoring event) and June 2013 to account for water table fluctuations and to allow LNAPL, if present, to enter the well. Each well will be completed flush with the land surface with a bolt-down steel cover set inside a concrete pad. The location and elevation of each new monitoring well will be surveyed by a New York State-licensed land surveyor and referenced to the existing site datum. Standard well installation procedures are contained in Attachment A.

Monitoring Well Repairs

Five monitoring wells were damaged or lost during the ISS remedial construction project. These wells and actions to restore the wells are identified below.

- A new 2-inch diameter PVC monitoring well will be installed to replace monitoring well MW-14, which was lost during the remedial construction project. The new well (MW-14R) will be installed using the procedures described above for the new 4-inch diameter wells, except drilling will be performed using 4¼ inch HSAs.

- The surface completions (steel covers and flush-mount concrete pads) at monitoring wells MW-6 and MW-13 will be replaced.

- The locking tops for the protective casings of monitoring wells MW-17 and MW-18 will be replaced.

ARCADIS will measure the depth to the bottom of monitoring wells MW-6, MW-13, MW-17, and MW-18 and compare these measurements to the installed depth for each well. A bailer will also be lowered to the bottom of each well to confirm that the casing is not obstructed or partially filled with debris. The wells will be redeveloped if silt/debris is found to cover more than 25% of the well screen.

Community Air Monitoring

Community air monitoring for particulates and volatile organic vapors will be performed during well drilling and installation at one upwind and one downwind monitoring station. The air monitoring will be performed following the same protocols that were used for the ISS remedial construction project.

Monitoring Well Development

The new monitoring wells will be developed no sooner than 24 hours after installation is complete. New wells will be developed by alternately surging and pumping to remove sediment and improve the hydraulic connection between the well and the surrounding aquifer.

LNAPL Monitoring and Recovery

Water levels and the thickness of LNAPL, if present, will be gauged in the new monitoring wells (MW-31 through MW-34) and nearby downgradient monitoring wells (MW-6, MW-13, and MW-14R). If monitoring well MW-34 is not installed, water level measurement/LNAPL gauging will be performed at MW-29S instead.

Monitoring wells will be gauged during weekly site visits for a period of eight weeks. During each weekly site visit, any LNAPL present with a measured thickness of 0.5

inches (0.04 foot) or more will be removed using a bailer or peristaltic pump. To the extent possible based on observed LNAPL quantities, the rate of LNAPL recovery into the well will be assessed to determine an appropriate regular interval for LNAPL gauging and removal.

- It is estimated that observations of LNAPL recovery will be made over a period of several hours during the initial gauging event and that a site visit will be made the next day to further monitor and document the LNAPL recharge.
- For wells that regularly have measurable LNAPL, a passive diffusion bailer (passive recovery canister) may be used to facilitate recovery efforts.

If sufficient quantities of LNAPL are encountered, up to three samples of LNAPL from the wells will be submitted for laboratory testing to assess physical properties (viscosity, density, interfacial tension) and chemical composition (volatile organic compounds, semi-volatile organic compounds, and total petroleum hydrocarbons).

Investigation-Derived Waste Characterization

All investigation derived waste (IDW), including drill cuttings and decontamination/ well development water, will be contained in 55-gallon drums that will be staged onsite. IDW samples (one each for the IDW solids and liquids) will be collected and analyzed for waste-characterization parameters, and the IDW will be transported offsite for appropriate disposal.

Schedule and Reporting

The field work will be scheduled after receipt of written approval of this work plan from the New York State Department of Environmental Conservation (NYSDEC). We anticipate that the drilling, well installation and development, and well repairs will require approximately one week to complete, depending on conditions encountered. Weekly well gauging will continue for eight weeks. Please note that if the bailer currently silted in-place in well MW-29 cannot be removed and a replacement well needs to be installed on the grocery store property, the schedule for installation of that new well will depend on timing for a new access agreement with the property owner.

Periodic progress updates regarding the status of the water level/LNAPL gauging and removal activities, and a comprehensive letter report including recommendations will be prepared and submitted the NYSDEC. Progress updates will be provided following the first two weeks of the monitoring period, and midway through the eight-week monitoring period. The letter report will summarize the work performed and the findings of the weekly water level/LNAPL gauging and LNAPL recovery efforts, and present recommendations. The report will include the following:

- Tables presenting the water level/LNAPL gauging data, including quantities of water and LNAPL removed from the wells, and analytical results for any LNAPL characterization samples.

- Figures showing the site layout and surveyed locations for the new and existing groundwater monitoring wells.

- Appendices containing monitoring well completion logs and laboratory analytical data reports.

We anticipate submitting the letter report to the NYSDEC and the New York State Department of Health (NYSDOH) within approximately four to six weeks after the monitoring period is completed.

We will contact you during the week of June 10, 2013 to see if the NYSDEC has any comments or questions on this work plan. Please feel free to contact Tracy Blazicek (NYSEG) at 607.762.8839 or me at 315.671.9441 in the interim if you have any comments/questions or need additional information.

Sincerely,

ARCADIS of New York, Inc.

John C. Brussel

John C. Brussel, P.E.
Principal Engineer

Attachments:
Table 1 – Summary of February 2013 LNAPL and Water Level Gauging Data
Figure 1 – Existing and Proposed Monitoring Well Locations
Attachment A – Field Method Standard Operating Procedures

Copies:
Tracy Blazicek, CHMM, NYSEG
Keith White, C.P.G., ARCADIS

Table

Table 1
LNAPL Gauging & Removal Data for Monitoring Well MW-11

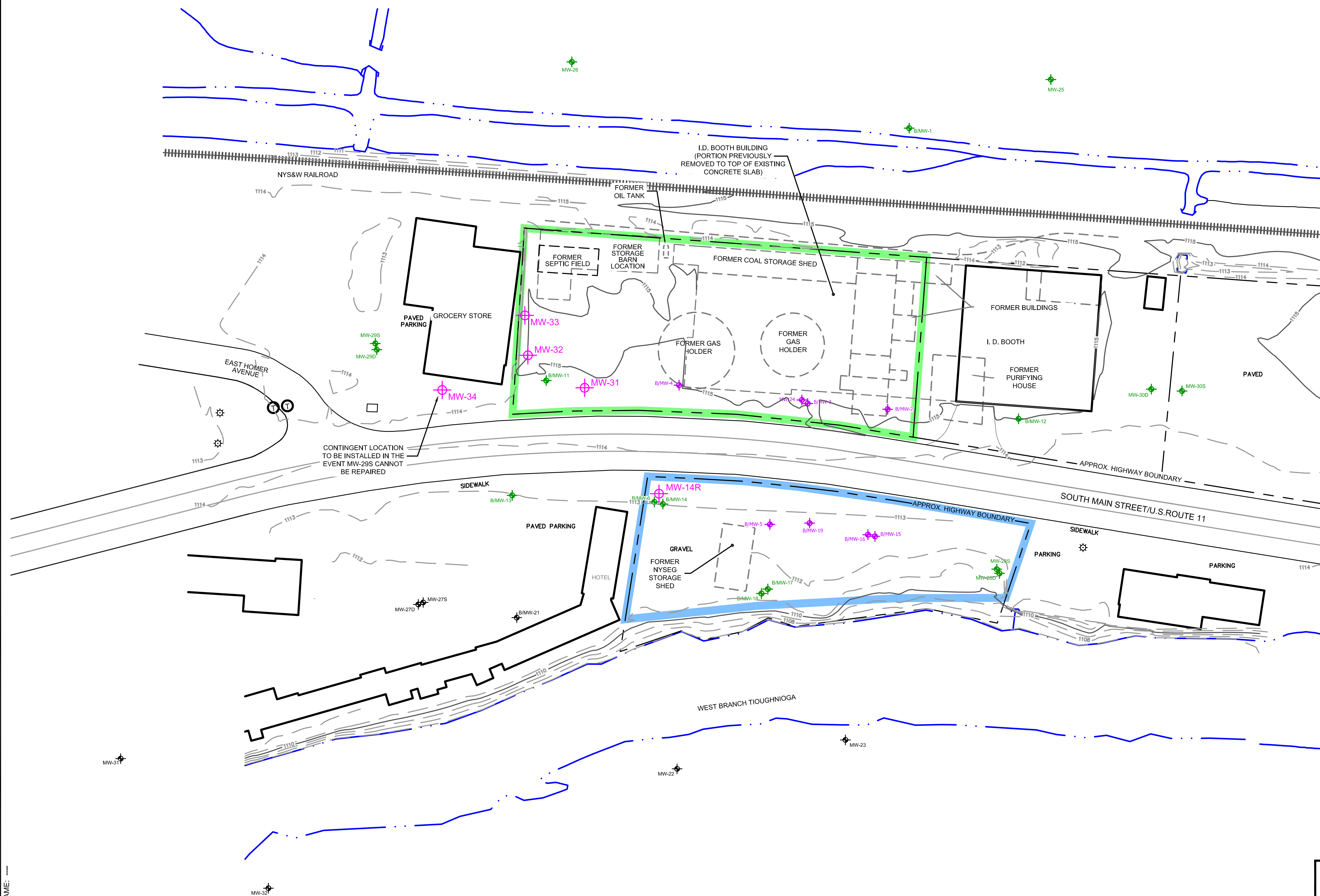
Operable Unit 1
New York State Electric & Gas Corporation
Cortland-Homer Former MGP Site
Homer, New York

Date	Time	Measured Depth (feet below TIC)		Approximate LNAPL Thickness (feet)		Approximate Volume Removed (gallons)		NAPL Removal Method (Peristaltic Pump/Bailer)
		to Water	to LNAPL	by Interface Probe	by bailer	LNAPL/Water Mixture	LNAPL	
2/4/2013	9:45	5.03	4.83	0.20	0.20	0.50	0.032	Bailer
2/5/2013	10:00	5.05	4.85	0.20	0.20	0.50	0.032	Bailer
2/6/2013	10:00	5.14	5.24	0.10	0.10	0.50	0.016	Bailer
2/7/2013	14:00	5.30	5.30 (trace)	trace	NM	0.5	Trace Blebs	Peristaltic Pump
	16:00	5.32	5.32 (trace)	trace	NM	0	0.00	Gauge Only
2/8/2013	9:45	5.31	5.31 (trace)	trace	trace	0.25	Trace Blebs	Bailer
	13:00	5.32	5.32 (trace)	trace	NM	0	0.00	Gauge Only
2/11/2013	9:30	5.37	trace	trace	trace	0	0.00	Gauge Only
	15:30	5.36	trace	trace	trace	0	0.00	Gauge Only
2/12/2013	10:15	5.49	trace	trace	trace	0	0.00	Gauge Only
	14:45	5.50	trace	trace	trace	0	0.00	Gauge Only
2/13/2013	10:30	5.56	trace	trace	trace	0	0.00	Gauge Only
	14:00	5.56	trace	trace	trace	0	0.00	Gauge Only
2/14/2013	10:45	5.56	trace	trace	trace	0	0.00	Gauge Only
	15:00	5.57	trace	trace	trace	0	0.00	Gauge Only
2/15/2013	11:25	5.56	trace	trace	trace	0	0.00	Gauge Only
	15:30	5.57	trace	trace	trace	0	0.00	Gauge Only
2/16/2013	10:35	5.57	trace	trace	trace	0	0.00	Gauge Only
	14:55	5.58	trace	trace	trace	0	0.00	Gauge Only
2/18/2013	11:35	5.54	trace	trace	trace	0	0.00	Gauge Only
	15:40	5.55	trace	trace	trace	0	0.00	Gauge Only
2/19/2013	9:30	5.61	trace	trace	trace	0	0.00	Gauge Only
	14:00	5.62	trace	trace	trace	0	0.00	Gauge Only
2/20/2013	10:00	5.67	trace	trace	trace	0	0.00	Gauge Only
	15:00	5.68	trace	trace	trace	0	0.00	Gauge Only
2/21/2013	9:00	5.73	trace	trace	trace	0	0.00	Gauge Only

Notes:

1. LNAPL = light non-aqueous phase liquid.
2. Top of inner casing (TIC) elevation for MW-11 is 1114.97 feet above mean sea level (AMSL) relative to the North American Vertical Datum of 1988 (NAVD88).
3. Depth to bottom of MW-11 is 11.16 feet below TIC.
4. NM = not measured.

Figure



LEGEND:

- PROPOSED MONITORING WELL
- EXISTING MONITORING WELL NOT IN MONITORING NETWORK
- FORMER MONITORING WELL LOCATION (DECOMMISSIONED IN JULY/AUGUST 2012)
- EXISTING MONITORING WELL IN MONITORING NETWORK
- REMOVED/FORMER BUILDINGS
- FORMER MGP STRUCTURE
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE HIGHWAY BOUNDARY
- OPERABLE UNIT 1
- OPERABLE UNIT 2

NOTES:

1. BASEMAP SUPPLIED BY AECOM OF LATHAM, NEW YORK DRAWING NUMBER 3 AT A SCALE OF 1"=60', ENTITLED "NYSEG - REMEDIAL DESIGN FOR FORMER CORTLAND-HOMER MGP SITE" DATED APRIL 16, 2012.
2. BASE MAPPING COMPILED FROM VARIOUS SOURCES INCLUDING NEW YOUR STATE ELECTRIC & GAS (NYSEG) EXISTING PLANIMETRIC AND UTILITY INFORMATION, DIGITIZED INFORMATION FROM NYSDOT RECORD PLANS TITLED RECONSTRUCTION OF ROUTE 11 IN THE TOWN OF CORTLANDVILLE AND VILLAGE OF HOMER - DATED 5-17-02, DIGITIZED AERIAL IMAGERY FROM THE NEW YORK STATE GIS CLEARINGHOUSE, AND A FIELD SURVEY PERFORMED BY AECOM - DATED MAY 13, 2011.
3. FORMER SEPTIC SYSTEM AND OIL TANK TAKEN FROM A PLAN ENTITLED "INVESTIGATION OF FORMER COAL GASIFICATION SITES", DATED 1987 BY E.C. JORDAN CO..
4. ALL LOCATIONS ARE APPROXIMATE.

0 80' 160'
GRAPHIC SCALE

NYSEG
FORMER CORTLAND-HOMER MGP SITE
HOMER, NEW YORK
SUPPLEMENTAL LNAPL INVESTIGATION

EXISTING AND PROPOSED MONITORING WELL LOCATIONS

ARCADIS

FIGURE
1

CITY:SYRACUSE, NY DIV/GROUP:ENV/REM-WIM-DV DB: A. SCHILLING, R. BASSETT, P. LISTER PM: J. BRUSSEL TM: J. BRUSSEL TR: M. HYSELL LYR:ON=*;OFF=*REF* BY: LISTER, PAUL
G:\ENVCAD\SYRACUSE\ACT\B0013123\0006\00001\DWG\13123B02.dwg LAYOUT: 1 SAVED: 6/4/2013 8:18 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/4/2013 8:20 AM
XREFS: 13123X00 13123X03 13123X01 13123X02 IMAGES: PROJECTNAME: ----

ARCADIS

Attachment A

Soil Drilling/Sample Collection and Monitoring Well Installation Standard Operating Procedures

ARCADIS
Infrastructure, environment, buildings

Imagine the result

Soil Drilling and Sample Collection

Rev. #: 2

Rev Date: March 8, 2011

Approval Signatures

Prepared by: _______________ Date: 03/08/2011

Reviewed by: _______________ Date: 03/08/2011
(Technical Expert)

I. Scope and Application

Overburden drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary. Direct-push techniques (e.g., Geoprobe or cone penetrometer) may also be used. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

II. Personnel Qualifications

The Project Manager (a qualified geologist, environmental scientist, or engineer) will identify the appropriate soil boring locations, depth and soil sample intervals in a written plan.

Personnel responsible for overseeing drilling operations must have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

III. Equipment List

The following materials will be available during soil boring and sampling 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;
- drilling equipment required by the American Society for Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);

- equipment cleaning materials;
- appropriate sample containers and labels;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID); and
- field notebook and/or personal digital assistant (PDA).

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be identified by one of the following three actions (lines of evidence):

- Contact the State One Call
- Obtain a detailed site utility plan drawn to scale, preferably an “as-built” plan
- Conduct a detailed visual site inspection

In the event that one or more of the above lines of evidence cannot be conducted, or if the accuracy of utility location is questionable, a minimum of one additional line of evidence will be utilized as appropriate or suitable to the conditions. Examples of additional lines of evidence include but are not limited to:

- Private utility locating service
- Research of state, county or municipal utility records and maps including computer drawn maps or geographical information systems (GIS)
- Contact with the utility provider to obtain their utility location records
- Hand augering or digging
- Hydro-knife
- Air-knife
- Radio Frequency Detector (RFD)

- Ground Penetrating Radar (GPR)
- Any other method that may give ample evidence of the presence or location of subgrade utilities.

Overhead power lines also present risks and the following safe clearance must be maintained from them.

Power Line Voltage Phase to Phase (kV)	Minimum Safe Clearance (feet)
50 or below	10
Above 50 to 200	15
Above 200 to 350	20
Above 350 to 500	25
Above 500 to 750	35
Above 750 to 1,000	35

ANSI Standard B30.5-1994, 5-3.4.5

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling borehole will be obtained, reviewed and approved to meet project quality objectives.

V. Health and Safety Considerations

Field activities associated with overburden drilling and soil sampling will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

<u>Drilling Procedures</u>

The drilling contractor will be responsible for obtaining accurate and representative samples; informing the supervising geologist of changes in drilling pressure; and keeping a separate general log of soils encountered, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments). The term “samples” means soil materials from particular depth intervals, whether or not portions of these materials are submitted for laboratory analysis. Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill. Where a boring cannot be advanced to the desired depth, the boring will be abandoned and an additional boring will be advanced at an adjacent location to obtain the required sample. Where it is desirable to avoid leaving vertical connections between depth intervals, the borehole will be sealed using cement and/or bentonite. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location.

Soil Characterization Procedures

Soils encountered while drilling soil borings will be collected using one of the following methods:

- 2-inch split-barrel (split-spoon) sampler, if using the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils

- Plastic internal soil sample sleeves if using direct-push drilling.

Soils are typically field screened with an FID or PID at sites where volatile organic compounds are present in the subsurface. Field screening is performed using one of the following methods:

- Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings should be obtained at several locations along the length of the sample

- A portion of the collected soil is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pieced with the FID or PID probe, and a reading is obtained.

Samples selected for laboratory analysis will be handled, packed, and shipped in accordance with the procedures outlined in the Work Plan, FSP, or Chain-of-Custody, Handling, Packing, and Shipping SOP.

A geologist will be onsite during drilling and sampling operations to describe each soil interval on the soil boring log, including:

- percent recovery;
- structure and degree of sample disturbance;
- soil type;
- color;
- moisture condition;
- density;
- grain-size;
- consistency; and
- other observations, particularly relating to the presence of waste materials

Further details regarding geologic description of soils are presented in the Soil Description SOP.

Particular care will be taken to fully describe any sheens observed, oil saturation, staining, discoloration, evidence of chemical impacts, or unnatural materials.

VII. Waste Management

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. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

The supervising geologist or scientist will be responsible for documenting drilling events using a bound field notebook and/or PDA to record all relevant information in a clear and concise format. The record of drilling events will include:

- start and finish dates of drilling;
- name and location of project;
- project number, client, and site location;
- sample number and depths;
- blow counts and recovery;
- depth to water;
- type of drilling method;
- drilling equipment specifications, including the diameter of drilling tools;
- documentation of any elevated organic vapor readings;
- names of drillers, inspectors, or other people onsite; and
- weather conditions.

IX. Quality Assurance

Equipment will be cleaned prior to use onsite, between each drilling location, and prior to leaving the site. Drilling equipment and associated tools, including augers, drill rods, sampling equipment, wrenches, and other equipment or tools that may have come in contact with soils and/or waste materials will be cleaned with high-pressure steam-cleaning equipment using a potable water source. The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone. More elaborate cleaning procedures may be required for reusable soil samplers (split-spoons) when soil samples are obtained for laboratory analysis of chemical constituents.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Monitoring Well Installation

Rev. #: 3

Rev Date: February 2, 2011

Approval Signatures

Prepared by: ______________________ Date: 2/2/2011

Reviewed by: ______________________ Date: 2/2/2011
(Technical Expert)

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) bulk hydraulic conductivity testing of formations adjacent to the open interval of the well.

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), 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 or Rotasonic methods. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, 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. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

II. Personnel Qualifications

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.

III. Equipment List

The following materials will be available 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;
- drum labels as required for investigation derived waste handling;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID);
- 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);

- field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, 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;
- drums for investigation derived waste;
- drilling and sampling equipment decontamination materials;
- decontamination pad materials, if required; and
- well construction materials.

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See separate SOP for utility clearance.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the DNAPL Contingency Plan SOP for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency

Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the material compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present. In these situations, neat cement grout is preferred.

No coated bentonite pellets will be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Monitoring wells may be installed with Schedule 40 polyvinyl chloride (PVC) to a maximum depth of 200 feet below ground surface (bgs). PVC monitoring wells between 200 and 400 feet total depth will be constructed using Schedule 80 PVC. Monitoring wells deeper than 400 feet will be constructed using steel.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedures

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan and/or FSP. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces large-diameter soil cores that tend to be more disturbed than split-spoon samples due to the vibratory action of the drill casing. Dual-rotary removes cuttings by compressed air and allows only a general assessment of geology. High-quality bedrock samples can be obtained by coring.

3. Describe each soil or bedrock sample as outlined in the appropriate SOP. Record descriptions in the field notebook and/or personal digital assistant (PDA). It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used. When drilling in bedrock, the rate of penetration (minutes per foot) is recorded.

4. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground

surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

5. In consolidated formations such as competent bedrock, a monitoring well may be completed with an open borehole interval without a screen and sandpack. In these cases, the borehole is advanced to the targeted depth of the top of the open interval. A permanent casing is then grouted in place following the procedures described in Step 4 above. After the grout sets, the borehole is advanced by drilling through the permanent casing to the targeted bottom depth of the open interval, which then serves as the monitoring interval for the well. If open-borehole interval stability is found to be questionable or if a specific depth interval is later selected for monitoring, a screened monitoring well may later be installed within the open-borehole interval, depending on the annular space and well diameter requirements.

6. Before installing a screened well – or after drilling an open-bedrock well –, it is important to confirm that the borehole has been advanced into the saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled without using water (e.g., hollow-stem auger, cable-tool, air rotary, air hammer), verify the presence of groundwater (and /or LNAPL, if applicable) in the borehole using an electronic water level probe, oil-water interface probe, or a new or decontaminated bailer. For boreholes drilled using water (e.g., drive and wash, spun-casing with roller-bit wash, rotasonic, or water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. In most cases, the well should be installed at least five feet below the water-table depth, determined as described above. When in doubt, err on the side of slightly deeper well installation.

If necessary, the borehole should be drilled deeper to ensure that the well may intersects the water table or a permeable water-bearing zone.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded PVC or stainless steel slotted well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation. Typically, the slot size will be 0.010 inch and the sand pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent sand pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent sand pack may be preferred. To the extent practicable, the slot size and sand pack gradation may be predetermined in the Work Plan or FSP based on site-specific grain-size analysis or other geologic considerations or monitoring objectives. A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump will be backfilled with neat cement grout to the bottom of the well screen prior to placing the sand pack around the screen. A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centralizing the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen. The sand pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. The sand pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan or FSP. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite

should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No coated bentonite pellets will be used in monitoring well drilling or construction. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 feet bgs.

9. Place a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.

   When an above-grade completion is used, the PVC riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the PVC riser will be sealed using an unvented, expandable locking plug.

10. 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.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff/medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.

2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan. Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan and/or FSP.

3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Step 7 and 8 above.

4. Install protective steel casing or flush-mount, as appropriate, as described in Step 9 above. During well installation, record construction details and tabulate materials used.

5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

VII. Waste Management

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan, FSP, and/or IDW management SOP.

VIII. Data Recording and Management

Drilling activities will be documented in a field notebook. 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 using the method specified in the site Work Plan. 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. 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 Assurance

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. Well materials will also be cleaned prior to well installation.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.