Environment

Prepared for:
Orange and Rockland Utilities
3 Old Chester Road
Goshen, NY 10924

Prepared by:
AECOM
Chelmsford, MA
July 18, 2013

Remedial Design Work Plan

Clove and Maple Ave. Former MGP Site
Haverstraw, Rockland County
NYSDEC Site # 3-44-049

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Prepared By: Thomas P. Clark, P.E.

Aimee Fitzpatrick

Reviewed By: Aimee Fitzpatrick, P.E.

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Certification

I, Thomas P. Clark, certify that I am currently a NYS registered professional engineer and that this Remedial Design Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

7/18/13

Thomas P. Clark
Registered Professional Engineer
New York License No. 085258

Date

1.0 Introduction

On behalf of Orange and Rockland Utilities, AECOM Environment has prepared this Remedial Design Work Plan (RDWP) for the remediation of impacted soils and groundwater within Operable Unit # 2 (OU-2), at the Orange and Rockland (O&R) Haverstraw Clove and Maple Former Manufactured Gas Plant (MGP) Site (Site) located in Rockland County, New York (Figure 1-1). Figure 1-2 shows the layout of the Site. This RDWP provides the guidelines to implement the remedy selected by the New York State Department of Environmental Conservation (NYSDEC) in accordance with the Record(s) of Decision (ROD, NYSDEC, 2012) and the Administrative Order on Consent (CO, Index No. D3-0001-99-01) between NYSDEC and Orange and Rockland Utilities (NYSDEC, 1999). This work plan has been prepared in accordance with NYSDEC's Technical Guidance for Site Investigation and Remediation (DER-10).

O&R has performed a series of environmental studies focusing on the Site and nearby properties. An Initial Hazard Assessment was completed in 1996, followed by a Preliminary Site Assessment in 1997 and a Surface Soil and Risk Assessment in 1998. A Remedial Investigation (RI) was started in 1998; this was composed of multiple phases of field work, analysis, and review. The RI produced several reports, and resulted in a DEC-approved Remedial Investigation Report (RIR) in May 2009 (CMX, 2009). Following the acceptance of the RIR, a Feasibility Study (FS) was begun by GEI. During this process the Site was broken into three Operable Units (OUs), consisting of:

OU-1: The MGP parcel owned by O&R and the drainage swale located between the O&R property and 104 Maple Avenue.

OU-2: The off-site properties including: the Apartment Complex property comprising four apartment buildings on Maple Avenue and one apartment building on West Street ; single-family row house residential properties on Maple Avenue, consisting of four adjacent properties at 111, 113, 115, and 117 Maple Avenue; and single-family residential properties on West Street, consisting of six properties at 96, 100, 102,104, 108, and 116 West Street. All of these properties are zoned residential. OU-2 also includes a portion of the Alleyway between the rear property line of 103 Maple Avenue and residential properties on West Street and a portion of Maple Avenue between 103 and 131 Maple Avenue.

OU-3: Sediments in the nearby Hudson River embayment.

The triangular parcel at the intersection of Maple Avenue and West Street, owned by the Village of Haverstraw, and the parcel at 146 Maple Avenue, which houses the Head Start facility, were included in the RIR study area but were deemed to be substantially unimpacted by the MGP, and so were not included in the areas requiring remedial action. After a public meeting and responsiveness survey, NYSDEC issued a Record of Decision (ROD) (NYSDEC, 2012) for the Site in March 2012. The ROD addressed environmental impacts in OU-1 and OU-2. Impacts in OU-3 will be addressed later.

1.1 DER-10 Requirements

A copy of the ROD has been included as Appendix A of this document to satisfy the following RDWP requirements of DER-10:

- Summary of the Remedial Investigation Report, provided in Section 6.1 of the ROD.
- Summary of sampling results collected up to the date of the publication of the ROD.
- Figures identifying all areas where the remedial action will be conducted.
- Figures showing the vertical and horizontal extent of the area to be remediated.

1.2 Nature and Extent of Contamination

As specified in DER-10, if the Remedial Investigation and Feasibility Study have been approved by NYSDEC and a ROD has been issued, no summary of nature and extent of contamination is required in the RDWP. A copy of the ROD is included in Appendix A.

1.3 Selected Remedy

A full description of the selected remedy is documented in the ROD, including proposed changes based on changes in site redevelopment plans, and is presented in Section 3.2. A copy of the ROD is included in Appendix A.

1.4 Standards, Criteria, and Guidance

Remedial actions are required to meet the requirements of applicable environmental laws, regulations, ordinances, standards, and guidance documents. These are known as Standard Criteria and Guidance, or SCGs. SCGS dictate the cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations which are generally applicable, consistently applied, officially promulgated and are directly applicable to a remedial action.

The principal SCGs applicable to this Site are:

- *6 NYCRR § 375-1: General Remedial Program Requirements*
- *6 NYCRR§ 375-2: Inactive Hazardous Waste Disposal Site Remedial Program*
- *6 NYCRR§ 375-6: Remedial Program Soil Cleanup Objectives*
- *Draft NYSDEC Policy Memorandum on Soil Cleanup Guidance (Soil Cleanup Memo), November 4, 2009*
- *6 NYCRR Parts 700-706 Water Quality Regulations*
- *Guidance for Evaluating Soil Vapor Intrusion in New York*
- *DER-10*
- *TAGM 4030-Selection of Remedial Actions at Inactive Hazardous Waste Sites*

2.0 Design Investigations

During preparation of the FS and the RDWP, additional information was identified as necessary to complete the remedial design. A pre-design investigation will be performed to gather the required information.

2.1 PDI Objectives

The purpose of the PDI is to gather the additional information required to design the selected remedy for the Site as specified in the ROD. The objectives of this PDI are:

- Collect geotechnical data, including blow counts, on the soils within and along the perimeter of the excavation areas for analysis and design of the excavation support system(s).
- Perform geotechnical testing of soils collected during subsurface borings for modeling soil conditions as part of excavation design.
- Collect analytical data to demonstrate the feasibility of reusing shallow, unsaturated site soils meeting the reuse criteria in 6 NYCRR Part 375 and DER-10 for site-specific residential soil cleanup objectives identified in Section 3.4.2. The site-specific SCO for total PAHs is 25 mg/kg. For all other constituents, SCOs for residential use established in 6 NYCRR Part 375 will be applied.
- Observe soil and groundwater behavior during test pitting on the Site to reveal potential constructability impediments.
- Record subsurface structures that may present obstructions during excavation, including utilities which will require demolition and/or relocation.
- Further delineate the vertical and horizontal limits of MGP-related impacts that require subsurface soil excavation via field classification of soils and analytical testing.
- Further investigate the Site hydrology to include seasonal and storm event fluctuations, reported artesian pressures in underlying soil layers, and soil permeability.
- Collect data on stormwater flows in the on-site storm sewer main and laterals to prepare for temporary bypass pumping during construction and review of adequacy of current configuration.
- Assess Site construction water discharge options based upon required sampling and available/allowable discharge capacities.
- Observe the construction and condition of the foundations of the Site buildings via interior inspections for the purpose of excavation design.
- Observe below grade construction of building foundations slated to be demolished, depending on access and schedule.
- Obtain a topographic, property boundary and utility survey to serve as the design base map. This survey will meet the DER- 33 requirements so that it can be used for deed restrictions that may be required following the completion of remedial construction.

Pre-characterization of soil to meet the requirements of off-site waste management facilities is not included as part of the proposed work. Waste characterization required to implement the remedial action will be performed later.

2.2 Pre-Design Investigation Scope and Rationales

The PDI will consist of the following activities:

- Geotechnical drilling will include hollow stem auger (HSA) methods and cased drive and wash rotary methods. Standard penetration testing (SPT) will be used to collect soil samples for geotechnical analysis and delineation of excavation limits.
- Direct-push drilling will be used to collect soil samples for chemical analysis to facilitate delineation of excavation limits and evaluations of potential soil reuse.
- Test pits will be excavated to collect information on subsurface features including the storm drain and other subsurface utilities and soil and groundwater characteristics.
- Physical soil testing will be performed to evaluate geotechnical properties.
- Storm sewer flow monitoring will be performed.
- Aquifer testing will be performed to allow evaluation of excavation dewatering requirements.
- Topographic, property boundary, and utility surveys will be completed to provide a Site map for remedial design and to meet requirements for utility protection.

Details of the pre-design investigation are presented in the Pre-design Investigation Work Plan included in Appendix B.

3.0 Design Scope

3.1 Design Activities

The ROD requires implementation of a remedial design program to allow construction, operation, maintenance, and monitoring of the remedial action. This section provides a conceptual design of construction activities. Discussion of operation, maintenance, and monitoring is described in Section 6.

Consistent with the requirements of DER-10, the remedial design will include the following elements:

- This Remedial Design Work Plan including a Pre-design Investigation Work Plan
- A pre-design investigation
- Sixty-five percent design documents
- Draft one hundred percent design documents and bid package
- One hundred percent design documents and bid package
- Project plans

Sixty-five percent design submittals will include drafts of the Remedial Design specifications, drawings, and project plans. Draft 100 percent design submittals will include revised drawings, specifications, and project plans incorporating NYSDEC's 65 percent design comments. One hundred percent design submittals will include final biddable quality specifications, drawings, and project plans and a package.

Project plans will be prepared to provide more detail of important aspects of construction activities. Specific plans to be provided include the following:

- Traffic Control Plan and Truck Routing Plan
- Water Management Plan
- Soil Management and Pre-characterization Plan
- Community and Environmental Response Plan (CERP)
- Community Air Monitoring Plan (CAMP)

3.2 Remedial Action Summary

The selected remedy for the Site described in the ROD includes the following construction activities:

- Excavation and off-site disposal of MGP impacted soils exceeding Soil Cleanup Objectives (SCOs) established in the ROD.
- Placement of a new or maintenance of an existing site cover consisting of either two feet of clean soil, pavement, sidewalks, or buildings in areas that are not remediated during the first phase of excavation.

- Installation of barriers between remaining contaminated areas under existing structures and excavated areas to prevent recontamination of remediated areas.
- Protection of the stormwater drainage line from contaminated materials during excavation or relocation as determined during the design phase.
- Implementation of odor, noise, and dust control measures during excavation to the extent practicable.
- Off-site or on-site treatment and disposal of groundwater extracted during construction in compliance with applicable discharge standards.

The ROD describes a remedy in OU-2 to be implemented in two phases. The first phase would include excavation of impacted soil within areas which are currently accessible. The second phase would include excavation of areas under existing buildings in the future if the buildings are demolished. O&R has been advised of plans for demolition of buildings located at 111 to 145 Maple Ave. and another on West St. by the property owner. The remedial design will be prepared based on the understanding that these structures will be removed prior to beginning of remedial construction, allowing for the remedy to be implemented in one phase rather than two. Other single family residential properties along West St. will remain. No excavation is required beneath the West St. single family residences.

In addition to these activities, the ROD includes a requirement that institutional and engineering controls and a Site Management Plan (SMP) be implemented. These are discussed in Section 6. Additionally, in-situ treatment of remaining groundwater to enhance natural attenuation may be implemented if required. Preparation of the SMP and design of an in-situ groundwater treatment system are not included in the design for OU-2.

Further description of the remedial construction activities required to implement this remedy is provided below.

3.3 Remedial Action Description

The following section describes the elements of the design basis that apply to the remedial design. Figure 3-1 presents the layout of the remedial action.

3.3.1 Site Preparation

The Site will be prepared for the required remedial actions and restoration work. The Site preparation activities include: mobilization; installation of security fencing; installation of erosion and sedimentation controls; installation of temporary site facilities; surveying to establish baseline conditions and grades; utility location, protection, and relocation if necessary; protection of existing structures, and implementation of traffic controls.

Engineering controls to control dust, odors, erosion, and stormwater will be mobilized, setup and installed prior to the start of intrusive activities.

3.3.2 Excavation of Impacted Soils

The estimated horizontal limits of excavation established by the FS and ROD are shown on Figure 3-1. The final required limits of excavation will be established based on SCOs discussed in Section 3.4 in comparison with soil analytical data from the RI and PDI. The maximum depth of excavation will be 15 feet except in locations where source material is present. Source material is defined as soil containing substantial DNAPL contamination in layers thicker than 0.2 feet. According to the ROD, the maximum expected depth of excavation is 25 feet.

In most areas of the site, shoring will be used to provide excavation support, protect structures and utilities, and provide groundwater cutoff. To the extent practical, excavation will be conducted inside temporary fabric structures using conventional earth moving equipment. Excavation will be sequenced in a series of cells, sized to allow efficient excavation and backfill using a single temporary fabric structure. To the extent practicable, the excavation cells will be designed with repeatable geometry, allowing efficient reuse of the shoring materials, as needed, without the need for extensive fabrication between cells.

Consideration will be given to excavating small or odd-shaped areas without a temporary structure. In that case, it may be necessary to move excavated soil into a temporary fabric structure for preparation (i.e., blending with admixtures) and subsequent load-out. This will minimize potential odor and dust impacts to the surrounding neighborhood. With this approach, excavation activities will be independent of off-site haul truck availability, allowing rapid excavation and minimizing the possibility of odor or dust migrating off the site into area occupied by the public.

The excavation cells will be positioned and sequenced so as to minimize risk of cross-contamination and facilitate construction traffic across the site and onto public roadways. The cell layout will also consider exiting utilities, notably the existing storm sewer line. It is anticipated that the existing storm sewer that crosses the site will be temporarily by-passed and then reconstructed at the existing alignment using similar materials. Alternatively the excavation work may be sequenced to facilitate reinstallation in a parallel alignment, reducing overall labor and material costs.

Geotechnical data generated by the pre-design investigation will allow for the design of shoring systems at the Site. Shoring will be implemented in areas where needed to provide support for utilities and structures. Shoring may also be incorporated in areas within the limits of excavation to provide support, allow for sequencing of excavation, and to reduce dewatering requirements within individual cells.

When excavation is complete in each area, soil compliance samples will be collected at the frequency specified in DER-10. DER-10 identifies two types of compliance sample, confirmation and documentation samples. In locations where excavation is completed to a depth less than 15 feet below the ground surface, confirmation samples will be collected for analysis to verify that SCOs have been achieved. In that case, the area will not be backfilled until the results of analysis provide the required verification.

If the bottom of excavation is at a depth greater than 15 feet, any source material which is present will be removed, if it is feasible. Following excavation to practicable limits, documentation samples will be collected to provide information on soil remaining on-site after remediation. In those locations, backfill may proceed immediately after samples have been collected.

3.3.3 On-site Waste Management

To the extent possible, all excavated soil will be loaded directly into trucks for off-site transportation to a permitted treatment or disposal facility. However, because of construction sequencing, off-site disposal facility scheduling issues, and waste characterization procedures, and in order to consolidate waste material for bulk truck shipments, it may be necessary to store waste material on-site prior to loading and shipment. In addition, materials that appear to be reusable may be stockpiled and evaluated for reuse on-site. In these instances, excavated soil will be transported by loader or on-site haul truck from the excavation areas to the stockpile area. The designated stockpiles of impacted materials will be equipped with liners and temporary covers. Temporary stockpiling during excavations of impacted material will be allowed provided it is on an area designated for excavation. The sequencing will be determined as construction progresses.

Large boulders or concrete footings may be encountered during excavation under the former residential buildings; they may require decontamination to meet disposal facility acceptance requirements. Decontamination will take place using brushes, steam cleaners, and/or pressure washers. Residues from decontamination operations will be collected and managed with impacted soils. Excavation debris may potentially be decontaminated and sent to an off-site facility for disposal. Decontamination water, as well as residuals from dewatering activities will be temporarily stored in appropriate tanks prior to treatment and management in the temporary water treatment system or transported to an appropriate off-site disposal facility as required.

The composition of the excavated soils are assumed to meet the requirements of "*Management Of Coal Tar Waste and Coal Tar Contaminated Soils and Sediment*" [(DER-4), NYSDEC, 2002], and can be managed as solid wastes at permitted off-site treatment or disposal facilities. Excavation below the water table will be necessary. Therefore, the design will address soil dewatering requirements including use of a staging area with a gravity sump to collect fluids, or local dewatering to draw groundwater levels below the excavation limit, with appropriate water management. If required, the soils will be amended with a drying agent such as cement kiln dust or absorbent polymer to facilitate transport to the off-site disposal facility. Quick lime or lime kiln dust greater than 50% available CaO and MgO are no longer acceptable to the NYSDEC for this purpose. All soil amendment activities will take place in a temporary fabric structure.

3.3.4 Waste Characterization

Soil that has been impacted by MGP residues will be classified as non-hazardous industrial waste unless they are determined to exhibit the characteristics of ignitability, corrosivity, reactivity, or toxicity characteristics leaching procedure (TCLP) benzene, as determined by laboratory testing. If they do exhibit one or more of these characteristics, they will be classified as hazardous wastes. The exception to this will be soils that exhibit only the TCLP benzene characteristic which will be sent for thermal treatment – such soils will be designated as Conditionally Exempt MGP Remediation Waste per "*Management of Coal Tar Waste and Coal tar Contaminated Soils and Sediment From Former Manufactured Gas Plants*" (DER-4; NYSDEC, 2002).

Soils will be characterized for waste disposal prior to excavation. Soil samples will be collected and analyzed for parameters required by specific permitted treatment and disposal facilities at the required frequency to allow direct loading and shipment of excavated material.

3.3.5 Off-site Transportation

Excavated materials will be transported off site in dump trucks to a treatment or disposal facility permitted to accept such material. Transportation of impacted materials from the Site will be performed in accordance with all regulatory requirements and in accordance with the Transportation Plan prepared as part of remedial design documents.

All haul trucks will have poly bed liners that fully line the bed of the truck and can be overlapped to cover the top of the load to manage odors during transportation. All loads must also be covered with solid fabric covers, no mesh covers will be allowed. Depending on loading practices, full decontamination of trucks may be required prior to leaving the Site. However, the design will specify that the vehicles will be loaded in such a way as to avoid contamination of their exteriors including tires.

Waste shipments will be documented using the required waste manifests. Other materials that have no specific documentation requirements will be documented using waste tracking forms, bills of lading, and receipts. All shipments of waste from the Site will be documented describing the type and amount of material and the receiving facility.

3.3.6 Excavation Dewatering and Water Management

Dewatering and construction water treatment systems will be required to maintain dry conditions during excavation and backfill. Groundwater elevation and flow data and groundwater chemistry data from the pre-design investigation will allow for the design of the dewatering and treatment systems. Artesian conditions have been reported at some locations on the Site and where necessary, dewatering specifications will include requirements for depressurizing the artesian aquifer so as to minimize risk of uncontrolled upward flow into excavations. Dewatering specifications will also include requirements for monitoring artesian pressures during construction to demonstrate that bottom of excavation will be stable and safe. Inflow rates will be estimated to allow proper sizing of water treatment systems.

Any construction water that is generated during the remedial action, including decontamination water and stormwater that comes in contact with open excavations, will be collected treated on-site and discharged to surface water or local publically owned treatment works (POTW) in accordance with requirements of a State Pollution Discharge Elimination System (SPDES) Permit and/or local sewer department requirements.

3.3.7 Site Restoration

Following all remedial activities, excavated areas will be backfilled to finish grade with clean imported fill or reusable on-site materials, in accordance with DER-10 provisions for importing backfill and soil reuse.

Excavated soil showing no signs of MGP impacts may be stockpiled for potential reuse. Before potentially reusable soil is used as backfill in any location, samples will be collected at the frequency required and analyzed for the constituents specified in DER-10, Chapter 5.4(e). Soil with no visible impacts and no odors and which does not contain debris or coal may be placed as backfill below a depth of 15 feet immediately without waiting for analytical results. Tested soil with concentrations of constituents less than 25 mg/kg total PAHs and less than residential use SCOs for other chemicals may be used as backfill at depths less than 15 feet. Specific procedures for backfill testing will be specified in a Soil Management and Pre-Characterization Plan.

3.3.8 Odor, Vapor, and Dust Control

Odor, vapor, and dust control will be conducted for this project due to the sensitive location of the Site and immediate proximity to residential and commercial buildings.

A variety of engineering controls will be available to control odors, vapors, and dust. The primary method of control will be completing work in a temporary fabric structure to the extent practicable. Additional controls may include, but will not necessarily be limited to, wetting soils with water to control dust, limiting the size of excavations, covering contaminated soils with plastic sheeting; use of odor suppressant foam; Biosolve® and possible use of other odor suppressant systems.

3.3.9 Air Monitoring

Community and work zone air monitoring will be performed per the NYSDOH and the Occupational Safety and Health Administration (OSHA) requirements, and according to the site-specific HASP (to be generated by the selected contractor) and CAMP. A Community Air Monitoring Plan (CAMP) will be prepared to meet the requirements of DER-10 as prescribed in the generic CAMP. The contaminants of concern at the Site are VOCs and particulates.

Community air monitoring will be continuous during activities capable of generating dust or releasing odors or vapors, such as site clearing, soil erosion fencing installation, excavation and handling of impacted soils, and backfilling and grading. Details of the community air monitoring program will be provided in the Community Air Monitoring Plan (CAMP).

Summaries of all air monitoring data will be provided to NYSDEC and NYSDOH on a weekly basis to facilitate the transfer of information related to protection of the local community.

3.3.10 Noise and Vibration Evaluation

The planned remediation activities have the potential to generate noise and vibrations. The potential for noise and vibration impacts associated with the remediation process will be evaluated as part of the design. If necessary, requirements to monitor and mitigate these impacts will be included in the design.

3.3.11 Erosion and Sediment Control

Remediation activities will disturb an area greater than one acre in size. For that reason, the SPDES General Construction Stormwater Permit GP-0-08-001 from Construction Activity (GP-02-01, April 2008) will be required. The permit, as well as local permitting rules, require preparation of a stormwater pollution prevention plan (SWPPP). Erosion and sedimentation best management practices (BMPs) will be planned and implemented in accordance with the New York State Stormwater Management Design Manual and New York Standards and Specifications for Erosion and Sediment Control.

Erosion will be prevented and sediment will be controlled during all land disturbing activities. Stormwater runoff will be controlled in a manner to prevent contact with impacted soils. Stormwater that does contact impacted soils will be collected and transported off-site to an approved water handling facility or to the on-site water treatment plant. Hay bales, silt fence, diversions, and other BMPs described in the SWPPP will be used as necessary to prevent erosion of exposed soils. Additional erosion control materials will be kept on site to immediately repair any deficiencies that are discovered during the inspections.

On-site decontamination pads will be used to remove mud from truck tires and prevent tracking of mud and impacted soil onto the streets. Detailed plans and specifications for erosion and sediment control will be provided with the design submittal.

3.3.12 Decontamination

During and upon completion of remediation activities, decontamination of equipment will be performed in order to prevent contaminated material from being spread off-site during waste hauling activities, and to prevent the spreading of impacted material to un-impacted areas of the Site. Trucks used for off-site transport of excavated material will be parked on plastic sheeting during loading to limit contact with impacted materials. Before they leave the site, trucks will be inspected and the extent of decontamination needed will be determined on a case by case basis.

An engineered equipment decontamination pad will be constructed to contain decontamination residues. When possible, trucks will be decontaminated using dry decontamination methods (i.e., removal of loose material with a broom or brush). If inspection determines that additional decontamination is required, wet decontamination using hoses or pressure washers will be performed.

Construction equipment will be decontaminated before it leaves areas of contamination in order to prevent tracking to unimpacted portions of the site. The method of equipment decontamination will consist of pressure washing to remove any impacted soil. Decontamination water generated during cleaning of tools and equipment will be collected on-site and disposed of at an approved water handling facility or treated on-site. Water generated from decontaminating personnel will be minimal due to the availability of disposable personal protective equipment (PPE) such as Tyvek coveralls, booties, and nitrile gloves. The volume of decontamination water generated from personnel decontamination is assumed to be negligible compared to equipment decontamination water, stormwater removal, and dewatering activities in the disturbed areas of the Site.

3.4 Design Requirements

3.4.1 Remedial Action Objectives

The remedial goals for the Site have been established through the remedy selection process stated in 6 NYCRR Part 375-1.10. As stated in the ROD, “The selected remedy is protective of human health and the environment, complies with state and federal requirements that are legally applicable or relevant and appropriate to the remedial action to the extent practicable, and is cost effective. The remedy utilizes permanent solutions and alternative treatment or resource recovery technologies, to the maximum extent practicable, and satisfies the preference for remedies that reduce toxicity, mobility, or volume as a principal element.”

In accordance with the ROD, the Remedial Action Objectives for Operable Unit 2 are as follows:

- <u>Groundwater</u>
  - RAOs for Public Health Protection
    - Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
  - RAOs for Environmental Protection
    - Prevent the discharge of contaminants to surface water.
    - Remove the source of ground or surface water contamination.
- <u>Soil</u>
  - RAOs for Public Health Protection
    - Prevent ingestion/direct contact with contaminated soil.
  - RAOs for Environmental Protection
    - Prevent migration of contaminants that would result in groundwater or surface water contamination.

- <u>Soil Vapor</u>
  - RAOs for Public Health Protection
    - Mitigate impacts to public health resulting from existing, or the potential for soil vapor intrusion into buildings at a site.

3.4.2 Soil Cleanup Objectives

The ROD has established soil cleanup objectives used to determine the required limits of excavation including the following:

- Twenty-five milligrams per kilogram (mg/kg) for total polynuclear aromatic hydrocarbons (PAHs)
- SCOs for residential land use established in 6 NYCRR 375-6.8 for other contaminants.

Achievement of these standards will allow residential use of the Site. Residential use standards are applied to soil at depths less than 15 feet below the ground surface. Removal or treatment of soil at depths greater than 15 feet is not required in order to allow residential use. In order to meet the RAO for removal of source material described in Section 3.4.1, the FS established the definition of source material as soil containing substantial DNAPL contamination in layers thicker than 0.2 feet. Soil with staining, sheens, or MGP odors will not be considered source material.

3.4.3. Property Access

In order to implement the remedial action for OU-2, access will be required to properties belonging to private owners and the Village of Haverstraw along Maple Ave. and West St. O&R has had preliminary discussions with these property owners about the planned activities. Implementation of all required remedial excavations cannot be completed until multi-unit residences located at 111 through 143 Maple Ave. and 130 West St. are demolished. The units in the building containing 111 through 117 Maple Ave. belong to individual owners. The buildings containing 119 through 143 Maple Ave. and 130 West St. are apartment buildings belonging to a single owner. Other single-family residences on West St. will remain in place during remedial action construction.

As indicated previously, O&R proposes to proceed with remedial design under the assumption that all required access will be available and buildings will have been removed at the time remedial construction begins. If that turns out not to be possible, the remedial design will be modified to allow implementation of as much of the work as possible.

3.4.4 Utilities

The selected remedial contractor will coordinate with Dig Safely New York to identify and verify the location of subsurface utilities within the work limits. Following mark-out, proposed boring or excavation locations will be staked out to ensure that the locations will be free and clear of underground utilities. During the excavation work utilities need to be relocated or protected to allow access of excavation equipment. Utility relocation and protection will be addressed within the remedial design.

3.4.3 Environmental Monitoring and Controls

Environmental controls will ensure that the work activities do not spread impacted soils and MGP waste outside the impacted areas and maintain the protection of human health and the environment throughout the remedial operations. These items will be covered in more detail in the Transportation Plan, CAMP, and HASP for the Site. These items will be submitted as part of the design.

3.4.4 Green Remediation

NYSDEC DER-31: Green Remediation (DER-31; NYSDEC, 2010b) requires that sustainable practices be considered during remedial design and construction. Specific practices identified in the ROD include the following:

- Considering the environmental impacts of treatment technologies in the long term;
- Reducing direct and indirect greenhouse gas and other emissions;
- Increasing energy efficiency and minimizing use of non-renewable energy;
- Conserving and efficiently managing resources and materials;
- Reducing waste, increasing recycling and increasing reuse of materials;
- Maximizing habitat value and creating habitat when possible;
- Fostering green and healthy communities and working landscapes which balance ecological, economic and social goals; and
- Integrating the remedy with the end use where possible.

Detailed plans and specifications for the entire remedy will be prepared in accordance with DER-31 as part of the design activities. DER-31 compliant practices and requirements will be clearly identified and provided to NYSDEC in the 65 percent design submittal.

4.0 Permitting and Other Authorizations

In addition to performance requirements established to ensure that the design of the remedial action meets the remedial action objectives set in the ROD (NYSDEC, 2009), the design will also be prepared to meet permitting and other regulatory requirements of local, state, and federal laws and regulations. As specified in Appendix 7B of the DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC, May 2010), the NYSDEC may grant exemption from most state permits required for completion of this remedial action, provided the substantive requirements of the permit programs are followed.

4.1 Construction Stormwater Permit

Remediation activities will disturb an area of greater than one acre and will require the SPDES General Construction Stormwater Permit GP-0-09-001 from Construction Activity (GP-02-01, April 2008). A notice of intent (NOI) will be filed with NYSDEC and a storm water pollution prevention plan (SWPPP) will be prepared and implemented. Copies of the NOI and SWPPP will be submitted to the village as part of the local permitting process.

4.2 Discharge Permit

Approval for discharge of treated groundwater collected during excavation dewatering will also be required. The water would be discharged to the locally owned public treatment works (POTW) or discharged to the local storm sewer system under a Special Pollutions Discharge Elimination System (SPDES) Permit.

4.3 Local Permits and Approvals

At an early stage in the design process, O&R will meet with local representatives to discuss permits and approvals for implementation of the work. Permits which may be required include the following:

- Land disturbing activity permit for clearing, filling, and grading;
- Building, electrical, and plumbing permits for temporary facilities and controls;
- Approvals for pipe hookups to storm drains or sanitary sewers for treatment system discharges; and
- Approvals for work on village property.

A review of information from the Federal Emergency Management Agency indicates that the Site is not located in a regulated flood plain area. Reviews of the NYSDEC Environmental Resource Mapper and the National Wetland Inventory indicate that federal and state freshwater wetlands are not located within Site boundaries. Wetland areas associated with the Hudson River embayment are located at a distance of about 100 feet from the Site boundary. In addition, the storm drain located at the Site discharges into the embayment.

5.0 Schedule

The schedule for remedial design activities is included in Figure 5-1.

6.0 Post-Construction Plans

In addition to the remedial construction activities described in Section 3, meeting ROD requirements may also require implementation of institutional and engineering controls once remedial construction is complete. These post-construction activities are not included in the remedial design.

6.1 Site Management Plan

As specified in DER-10, a Site Management Plan is required whenever site restrictions are required as part of a remedial action. The SMP will include the following elements:

- An Institutional and Engineering Control Plan that insures institutional and/or engineering controls remain in place and effective
- An Operations and Maintenance (O&M) Plan describing procedures for maintaining engineering controls
- Provisions for the management and inspection of the identified engineering controls and groundwater controls
- Groundwater monitoring plan to assess performance and effectiveness of the remedy; and
- A schedule of monitoring and frequency of submittals to NYSDEC.

6.2 Institutional and Engineering Controls

Institutional controls will be implemented in the form of environmental easements for the controlled properties that:

- Require the remedial party or site owners to complete and submit to the Department a periodic certification of institutional controls
- Restricts the use of groundwater as a source of potable or process water
- Prohibits the production of animal products for human consumption.
- Requires compliance with the Department approved Site Management Plan.

Elements of the remedial action which require ongoing operation, maintenance, or monitoring are considered engineering controls. As discussed previously, the site cover identified in the ROD, which would be an engineering control, is not required because excavation will be completed as a single project rather than in phases. The ROD specifies that the need for an in situ groundwater treatment system in OU-2 will be evaluated. If it is determined that implementation of in-situ groundwater treatment is required, that treatment system will be an engineering control.

7.0 References

CMX, 2009. Remedial Investigation Report, Former Clove and Maple Manufactured Gas Plant Site, 120 Maple Avenue, Haverstraw, NY. NYSDEC Site Number 3-44-049 . Prepared for: Orange and Rockland Utilities, Prepared by: CMX.

GEI, 2011. Feasibility Study, Clove and Maple Avenues Former Manufactured Gas Plant, Village Haverstraw, Rockland County, New York, NYSDEC Site No. 3-44-049. October 14, 2011.

NEA, 2000, Fish and Wildlife Impact Assessment, Former Manufactured Gas Plants, Haverstraw, New York, February, 2000.

NYSDEC, 2002. DER-4, Management of Coal Tar Waste and Coal Tar Contaminated Soils and Sediment from former MGPs (TAGM – 4061). January 2002.

NYSDEC 2006a. NYCRR PART 370 – 374 and PART 376 Environmental Remediation Programs.

NYSDEC, 2006b. 6 NYCRR PART 375 Environmental Remediation Programs Subparts 375-1 to 375-4 & 375-6. December 2006.

NYSDEC, 2012. Record of Decision, O&R, Haverstraw Clove & Maple MGP, Haverstraw, Rockland County, New York, Site No. 344049. March 2012.

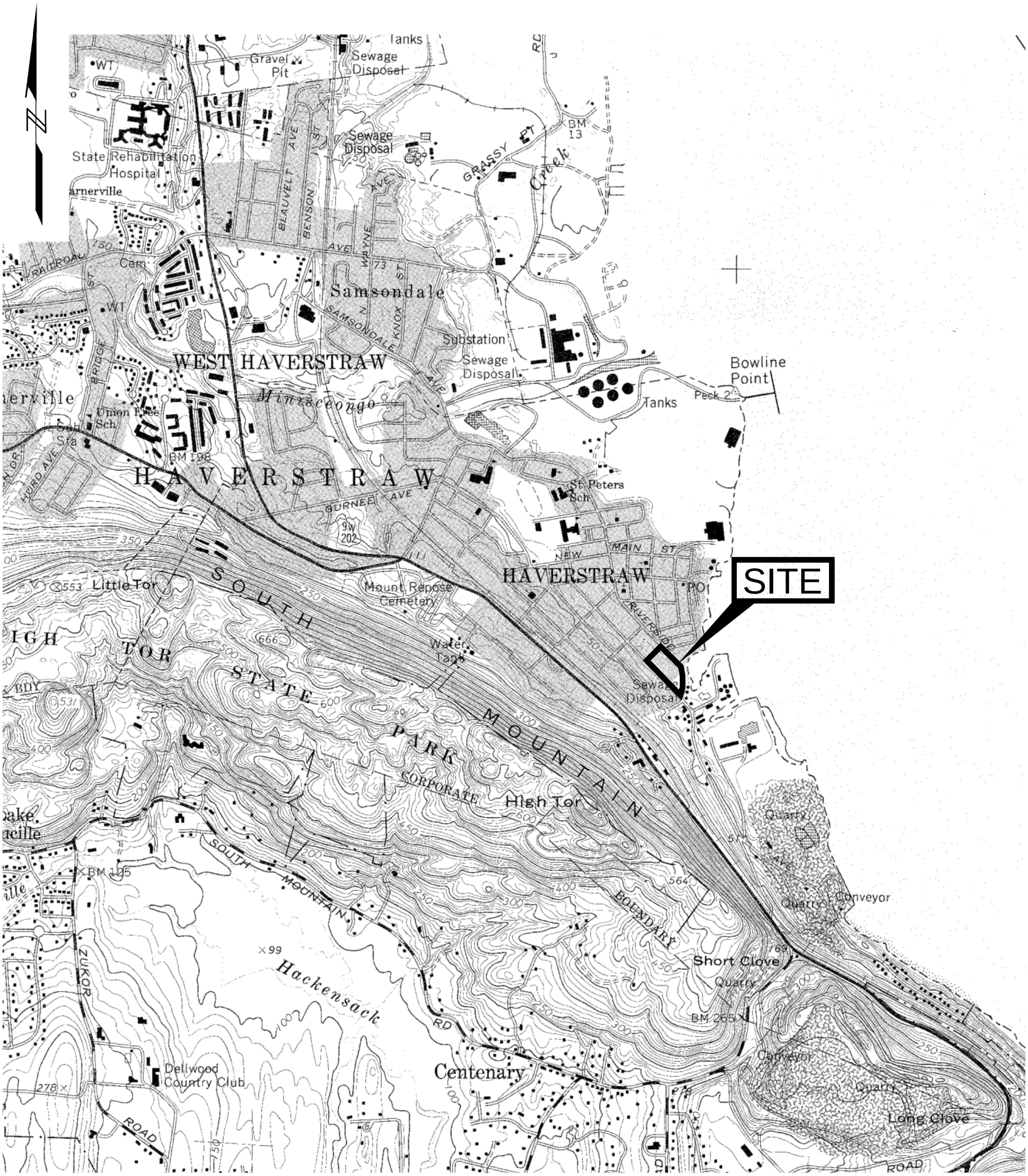
NYSDEC, 2010a. DER-10, Technical Guidance for Site Investigation and Remediation. May 2010.

NYSDEC, 2010b. DER-31, Green Remediation. September 2010.

RETEC, 1997. Surface Soil Investigation and Risk Assessment Report for Former MGP Site at Clove and Maple in Haverstraw, Prepared by Remediation Technologies, Inc. August 13, 1997.

RETEC, 2005. Clove and Maple Avenue Former MGP Sites, Haverstraw, NY. Soil Gas, Indoor and Ambient Air Sampling of February 2005. Preliminary Evaluation of Results. Prepared by The RETEC Group, Inc. March 23, 2005.

Figures



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SCALE, FEET

SOURCE: USGS TOPOGRAPHIC MAP, HAVERSTRAW, N.Y. 1979

AECOM

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

SITE LOCATION PLAN

DATE: 07/16/13 | DRWN: RCW

FIGURE 1-1

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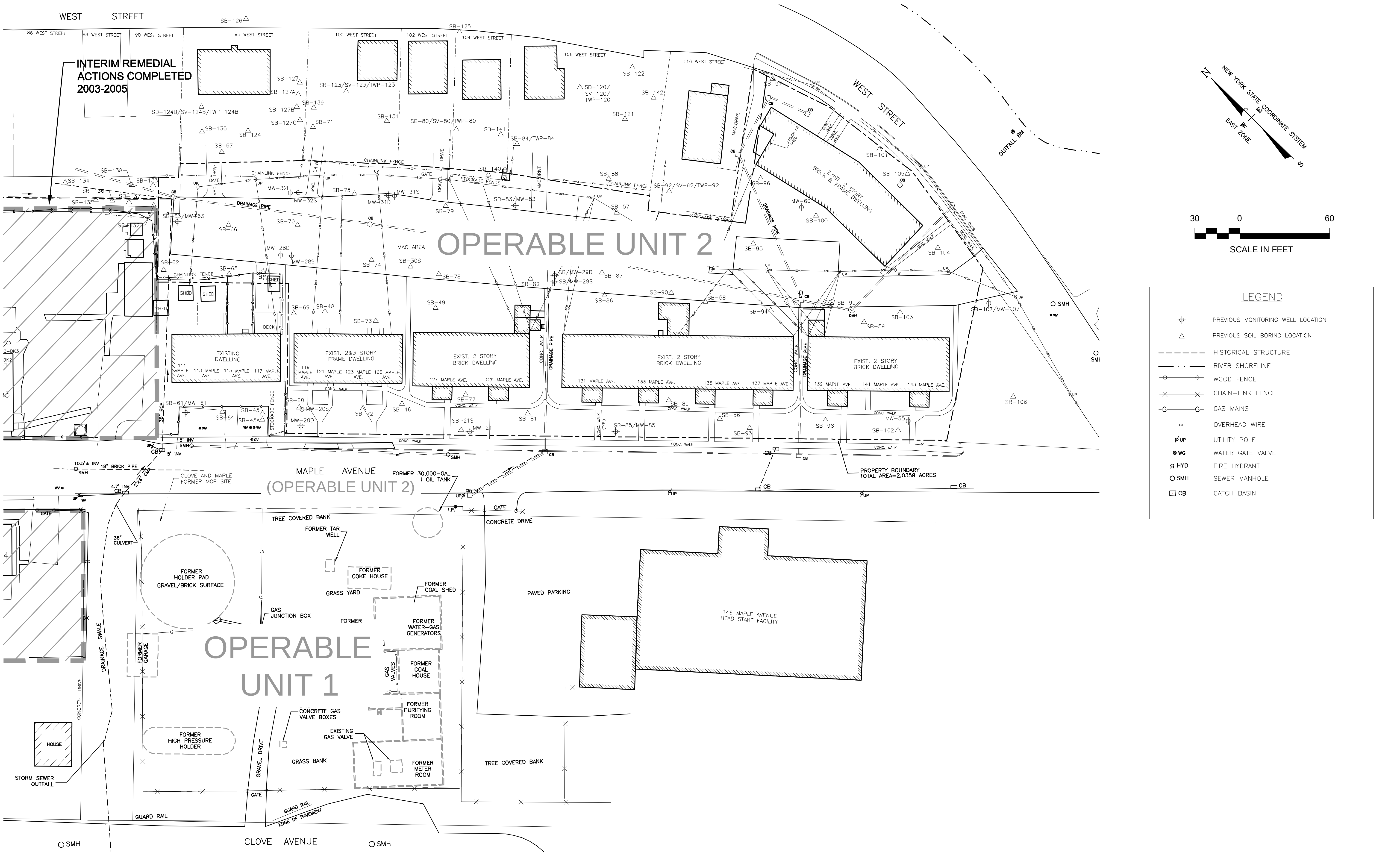


CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

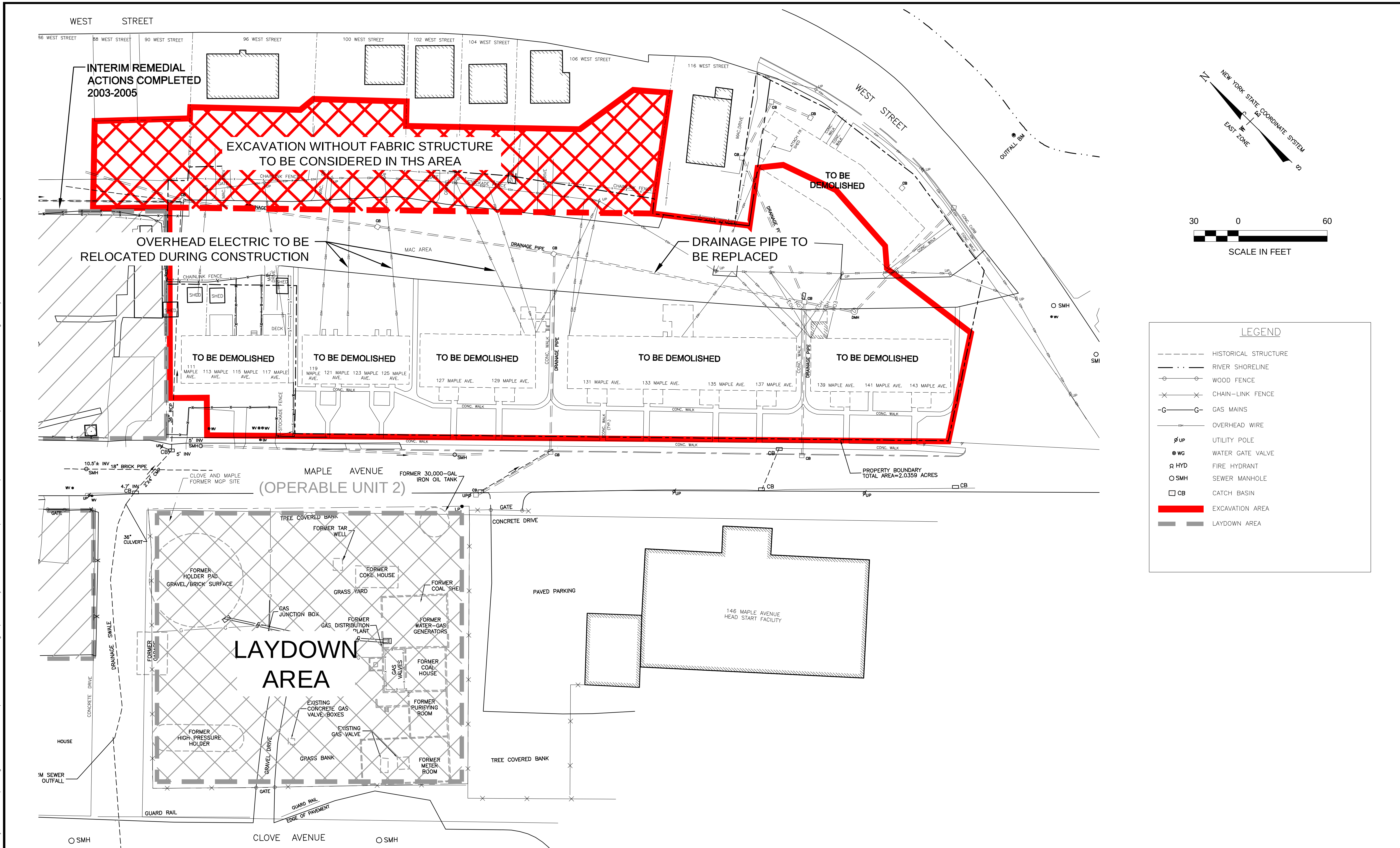
ORANGE AND ROCKLAND UTILITIES, INC.

DATE: 07/16/13 | DRWN: RCW

SITE LAYOUT

FIGURE 1-2

File: J:\Rem_Eng\Project Files\Orange & Rockland\Haverstraw Design\7.0 Project Documents\7.2 CADD\RDWP & PDWP\60288163-C-01.dwg Layout: Site Layout User: warrenr Plotted: Jul 16, 2013 - 2:54pm Xre



AECOM

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

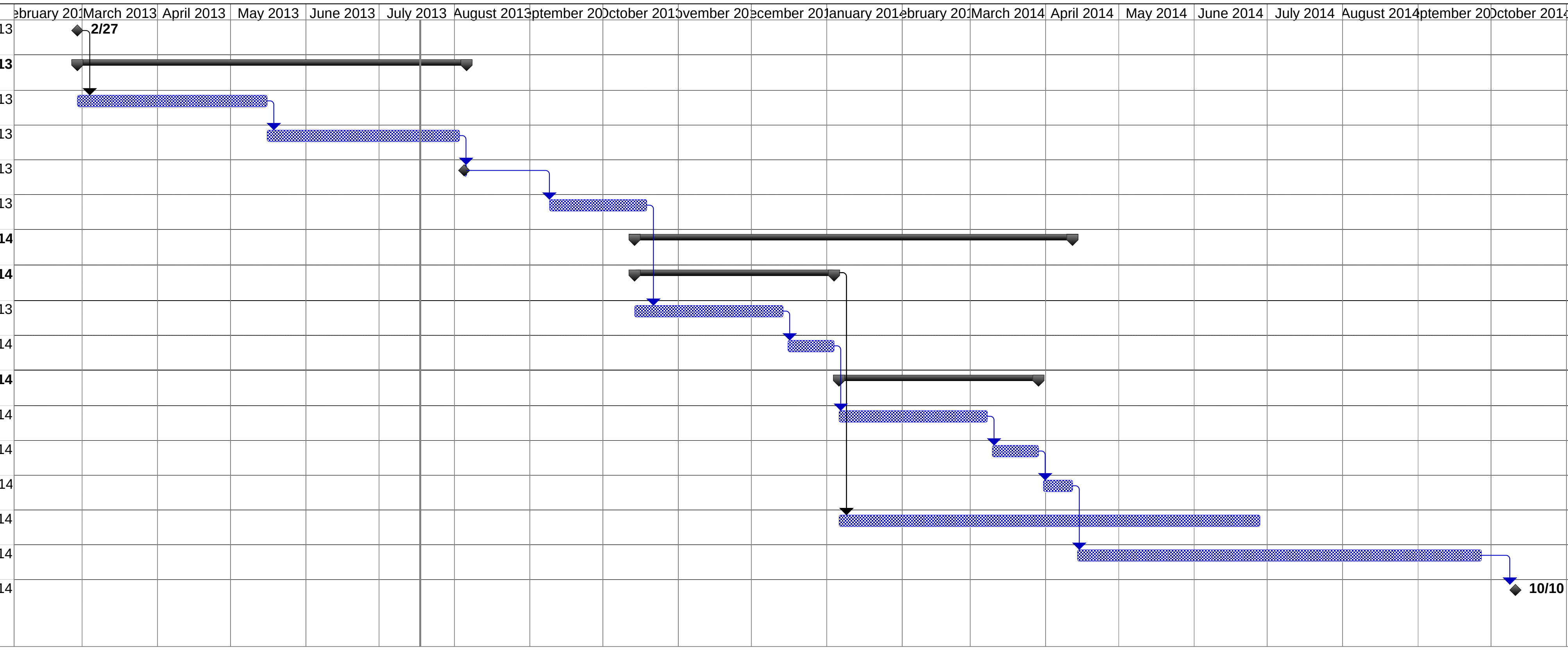
DATE: 07/16/13 | DRWN: RCW

REMEDIAL ACTION LAYOUT

FIGURE 3-1

TABLE 5-1
REMEDIAL DESIGN AND PROCUREMENT SCHEDULE
FORMER MANUFACTURED GAS PLANT SITE
HAVERSTRAW, NEW YORK

ID		Task Name	Duration	Start	Finish
1		Project Initiation	0 days	Wed 2/27/13	Wed 2/27/13
2		**Remedial Design Work Plan**	**114 days**	**Wed 2/27/13**	**Mon 8/5/13**
3		Prepare RDWP and PDIWP	56 days	Wed 2/27/13	Wed 5/15/13
4		NYSDEC Review	57 days	Thu 5/16/13	Fri 8/2/13
5		NYSDEC Approval	1 day	Mon 8/5/13	Mon 8/5/13
6		Pre-Design Investigation	30 days	Mon 9/9/13	Fri 10/18/13
7		**Design Drawings and Specifications**	**130 days**	**Mon 10/14/13**	**Fri 4/11/14**
8		**65% Design Drawings and Specifications**	**60 days**	**Mon 10/14/13**	**Fri 1/3/14**
9		Prepare 65% Design	45 days	Mon 10/14/13	Fri 12/13/13
10		NYSDEC Review	15 days	Mon 12/16/13	Fri 1/3/14
11		**100% Design**	**60 days**	**Mon 1/6/14**	**Fri 3/28/14**
12		Prepare Draft 100% Design and Bid Package	45 days	Mon 1/6/14	Fri 3/7/14
13		NYSDEC Review	15 days	Mon 3/10/14	Fri 3/28/14
14		Final 100% Design	10 days	Mon 3/31/14	Fri 4/11/14
15		Permitting and Access	125 days	Mon 1/6/14	Fri 6/27/14
16		O&R Procurement	6 mons	Mon 4/14/14	Fri 9/26/14
17		Contractor Mobilization - Date is dependent on property owner completing demolition of apartments	0 days	Fri 10/10/14	Fri 10/10/14



Appendix A

Record of Decision

RECORD OF DECISION

OR - Haverstraw Clove & Maple MGP
Operable Unit Number 02: Off site
Haverstraw, Rockland County
Site No. 344049
March 2012

Prepared by
Division of Environmental Remediation
New York State Department of Environmental Conservation

DECLARATION STATEMENT - RECORD OF DECISION

OR - Haverstraw Clove & Maple MGP
Operable Unit Number: 02
Haverstraw, Rockland County
Site No. 344049
March 2012

Statement of Purpose and Basis

This document presents the remedy for Operable Unit Number: 02: Off site of the OR - Haverstraw Clove & Maple MGP site. The remedial program was chosen in accordance with the New York State Environmental Conservation Law and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR) Part 375, and is not inconsistent with the National Oil and Hazardous Substances Pollution Contingency Plan of March 8, 1990 (40CFR300), as amended.

This decision is based on the Administrative Record of the New York State Department of Environmental Conservation (the Department) for Operable Unit Number: 02 of the OR - Haverstraw Clove & Maple MGP site and the public's input to the proposed remedy presented by the Department. A listing of the documents included as a part of the Administrative Record is included in Appendix B of the ROD.

Description of Selected Remedy

The elements of the selected remedy are as follows:

1) A remedial design program will be implemented to provide the details necessary for the construction, operation, maintenance, and monitoring of the remedial program. Notably a pre-design investigation will be performed to determine the depth and extent of excavation for those properties which were not fully delineated during the RI. Green remediation principles and techniques will be implemented to the extent feasible in the design, implementation, and site management of the remedy as per DER-31. The major green remediation components are as follows:

a) Considering the environmental impacts of treatment technologies and remedy stewardship over the long term;
b) Reducing direct and indirect greenhouse gas and other emissions;
c) Increasing energy efficiency and minimizing use of non-renewable energy;
d) Conserving and efficiently managing resources and materials;
e) Reducing waste, increasing recycling and increasing reuse of materials which would otherwise be considered a waste;
f) Maximizing habitat value and creating habitat when possible;
g) Fostering green and healthy communities and working landscapes which balance ecological, economic and social goals; and

h) Integrating the remedy with the end use where possible and encouraging green and sustainable re-development.

2) Excavation and off-site disposal of MGP impacted soil at properties located on West Street, 111-117 Maple Avenue; the Apartment Complex and the alleyway. Soil cleanup objectives (SCOs) to allow the residential use of the site will guide the excavation of contaminated soils with the exception of use of the site-specific SCO for total PAHs of 25 ppm based on background conditions. Approximately 30,000 cubic yards of soil will be removed and sent off site for disposal at a permitted facility. Clean fill meeting the requirements of 6 NYCRR Part 375-6.7d will be brought in to replace the excavated soil. No demolition of occupied buildings is anticipated.

3) The existing buildings and pavement at the site will form a portion of the site cover. Where there will be exposed surface soil, a site cover will be maintained as a component of any future site development, which will consist either of the structures such as buildings, pavement, sidewalks comprising the site development or a soil cover in areas where the upper two feet of exposed surface soil will exceed the applicable soil cleanup objectives (SCOs). Where the soil cover is required it will be a minimum of two feet of soil, meeting the SCOs for cover material as set forth in 6 NYCRR Part 375-6.7(d) for restricted residential use. The soil cover will be placed over a demarcation layer, with the upper six inches of the soil of sufficient quality to maintain a vegetation layer. Any fill material brought to the site will meet the requirements for the identified site use as set forth in 6 NYCRR Part 375-6.7(d).

4) A barrier will be in place in those areas where the excavation will not be completed beneath the existing structures to prevent recontamination of the remediated areas by contamination remaining under the buildings. The type of barrier will be determined during the design phase of the project.

5) Excavation activities will occur in the immediate vicinity of an existing stormwater drainage line to remove contaminated soil around or within the beddings of the drainage line. The need to protect or relocate the line to allow the necessary excavation will be determined during the design phase of the project, provided contaminated materials are addressed consistent with the remedial objectives and subject to field verification by the Department's on-site representative during construction.

6) Odor, noise and dust control measures including the use of a temporary structure (to the extent practicable) will be implemented during excavation to limit the impacts of remedial activities on the public. Groundwater extracted during construction will be sent off-site for treatment and disposal or treated on-site and discharged in compliance with applicable discharge standards

7) Following the excavation, if determined necessary, the remaining impacted site groundwater will be treated using an in-situ treatment technique to enhance natural attenuation. An oxygen injection system is currently being considered, with the final determination of the in-situ groundwater treatment to be made during the design phase of the project.

8) The site management plan (SMP) required for OU1 of the site will be developed and implemented to incorporate the OU2 remedy. The SMP will identify the institutional controls and engineering controls (IC/ECs) required for the remedy and detail their implementation. The plan will include, but may not be limited to:

a. an Engineering Control Plan that identifies all use restrictions and engineering controls for the site and details the steps and media-specific requirements necessary to ensure the following institutional and/or engineering controls remain in place and effective:

Engineering Controls: A site cover currently exists on the northern portion of OU2 and consists of buildings, pavement, sidewalks and landscaped areas. This cover will be maintained to allow for residential use of the site. Any site redevelopment will require remedial action in this area (see bullet 9 below). This plan includes, but may not be limited to:

i. Excavation Plan which details the provisions for management of future excavation in areas of remaining contamination;

ii. provisions for the management and inspection of the identified engineering controls and groundwater use controls;

iii. a groundwater monitoring plan to assess the performance and effectiveness of the remedy.

iv. a schedule of monitoring and frequency of submittals to the Department; and

9) Areas of subsurface contamination have been determined to currently be inaccessible due to the presence of buildings/structures; an unknown quantity of impacted material will remain in the front and under the existing buildings which may need to be addressed at a future point in time to complete this remedy. The impacted material will be subject to further characterization and removal and/or treatment, should the demolition of the buildings occur as part of a future redevelopment of this area.

New York State Department of Health Acceptance

The New York State Department of Health (NYSDOH) concurs that the remedy for this site is protective of human health.

Declaration

The selected remedy is protective of human health and the environment, complies with State and Federal requirements that are legally applicable or relevant and appropriate to the remedial action to the extent practicable, and is cost effective. This remedy utilizes permanent solutions and alternative treatment or resource recovery technologies, to the maximum extent practicable, and satisfies the preference for remedies that reduce toxicity, mobility, or volume as a principal element.

MArch 28, 2012

Date

RWSchick

Robert W. Schick, P.E., Acting Director
Division of Environmental Remediation

RECORD OF DECISION

OR - Haverstraw Clove & Maple MGP
Haverstraw, Rockland County
Site No. 344049
March 2012

SECTION 1: SUMMARY AND PURPOSE

The New York State Department of Environmental Conservation (the Department), in consultation with the New York State Department of Health (NYSDOH), has selected a remedy for the above referenced site. The disposal of hazardous wastes at the site has resulted in threats to public health and the environment that would be addressed by the remedy. The disposal or release of hazardous wastes at this site, as more fully described in this document, has contaminated various environmental media. The remedy is intended to attain the remedial action objectives identified for this site for the protection of public health and the environment. This Record of Decision (ROD) identifies the selected remedy, summarizes the other alternatives considered, and discusses the reasons for selecting the remedy.

The Department has issued this document in accordance with the requirements of New York State Environmental Conservation Law and 6 NYCRR Part 375. This document is a summary of the information that can be found in the site-related reports and documents.

SECTION 2: CITIZEN PARTICIPATION

The Department seeks input from the community on all remedies. A public comment period was held, during which the public was encouraged to submit comment on the proposed remedy. All comments on the remedy received during the comment period were considered by the Department in selecting a remedy for the site. Site-related reports and documents were made available for review by the public at the following document repository:

Haverstraw King's Daughters Library
Rosman Center - 10 West Ramapo Road
Garnerville, NY 10923
Phone: 845-786-3800

A public meeting was also conducted. At the meeting, the findings of the remedial investigation (RI) and the feasibility study (FS) were presented along with a summary of the proposed remedy. After the presentation, a question-and-answer period was held, during which verbal or written comments were accepted on the proposed remedy.

Comments on the remedy received during the comment period are summarized and addressed in the responsiveness summary section of the ROD.

Receive Site Citizen Participation Information By Email

Please note that the Department's Division of Environmental Remediation (DER) is "going paperless" relative to citizen participation information. The ultimate goal is to distribute citizen participation information about contaminated sites electronically by way of county email listservs. Information will be distributed for all sites that are being investigated and cleaned up in a particular county under the State Superfund Program, Environmental Restoration Program, Brownfield Cleanup Program, Voluntary Cleanup Program, and Resource Conservation and Recovery Act Program. We encourage the public to sign up for one or more county listservs at http://www.dec.ny.gov/chemical/61092.html

SECTION 3: SITE DESCRIPTION AND HISTORY

Location: The Orange and Rockland Utilities (O&R) Clove and Maple site is a former manufactured gas plant (MGP) and is located at 120 Maple Avenue in a residential and commercial portion of Haverstraw, Rockland County, New York. The Site is divided into three operable units (OU1-3). The main site (OU1) is approximately 1 acre in size and was operated from 1887 through 1935. The site ceased operation in 1935 after the introduction of natural gas in the area. The OU1 portion of the site is bounded by two residential properties to the northwest, a residential apartment complex and a former pond area to the northeast, Clove Avenue to the southwest and Maple Avenue to the southeast. OU portion consist of several residential properties including the apartment complex and is northeast of OU1. OU3 is the adjacent Hudson River Embayment east of OU2.

Site Features: The OU1 portion of the site is currently owned by O&R and was utilized as a natural gas regulator station until 2007 at which time the station was decommissioned. It is currently vacant and only the piping associated with the former regulator station remains at the site. OU2 portion of the site consist of several single family residents and apartment complex. OU3 is the adjacent Hudson River embayment with a stormwater discharge pipe.

Current Zoning/Uses: The OU1 portion of the site is zoned for light industrial uses while OU2 is zoned residential.

Historical Uses: The O&R Clove and Maple site was the location of a former gas manufacturing plant which operated from 1887 through 1935. The plant structures were demolished in the 1960s and the property was subsequently used as a natural gas regulator station. Prior to the MGP operations at the Clove and Maple site, a gas plant was in operation at 93B Maple Avenue. The 93B site (Site No. 344044) is located northwest of the Clove and Maple site on the opposite side of Maple Avenue. The 93B MGP Site and nearby properties were previously investigated and remediated in 2003 and 2005.

Operable Units: The site was divided into three operable units. An operable unit represents a portion of a remedial program for a site that for technical or administrative reasons can be addressed separately to investigate, eliminate or mitigate a release, threat of release or exposure pathway resulting from the site contamination. Operable unit 1 (OU1) is the on-site former MGP area (the O&R property) and drainage swale. OU2 consists of off-site properties including single family residential properties, an apartment complex, a portion of an alleyway, and a portion of Maple Avenue. OU3 consists of sediments in the Hudson River embayment located close to the site.

Site Geology and Hydrogeology: The site is located at the base of High Tor Mountain and is characterized by moderate relief with the ground surface sloping approximately 25 feet to the north. Site geology consists of four geologic units and they are from top to bottom: 1) fill, with thickness ranging from 5 feet to approximately 15 feet, and consisting of cobbles, gravel, cinders and coal; 2) alluvium (7 feet to 25 feet thick) consisting of silt and clay, including coarse-grained sand and gravel; 3) glacial lucustrine clay, with thickness ranging from 2 feet to 18 feet and; 4) clay consisting of dense silty clay with thickness ranging from 17 feet to about 36 feet. The on-site and off-site groundwater flows northeasterly towards a former pond area and the Hudson River. The former pond area is located under the apartment complex and its parking lot. This pond area was also part of a former stream channel that emptied into the Hudson River. The depth of groundwater varies throughout the site with typical depths of 5 feet to 8 feet below ground surface.

Operable Unit (OU) Number 02 is the subject of this document.

A Record of Decision was issued previously for OU 01. A Record of Decision will be issued for OU 03 in the future.

A site location map is attached as Figure 1.

SECTION 4: LAND USE AND PHYSICAL SETTING

The Department may consider the current, intended, and reasonably anticipated future land use of the site and its surroundings when evaluating a remedy for soil remediation. For this site, alternatives (or an alternative) that restrict(s) the use of the site to residential use (which allows for restricted-residential use, commercial use and industrial use) as described in Part 375-1.8(g) were/was evaluated in addition to an alternative which would allow for unrestricted use of the site.

A comparison of the results of the RI to the appropriate standards, criteria and guidance values (SCGs) for the identified land use and the unrestricted use SCGs for the site contaminants is included in the Tables for the media being evaluated in Exhibit A.

SECTION 5: ENFORCEMENT STATUS

Potentially Responsible Parties (PRPs) are those who may be legally liable for contamination at a site. This may include past or present owners and operators, waste generators, and haulers.

The PRPs for the site, documented to date, include:

Orange and Rockland Utilities, Inc.

This MGP Site is part of the Orange and Rockland Utilities (O&R) multi-site Consent Order. The Department and O&R entered into Consent Orders in January 8, 1996 (D3-0002-94-12) and September 29, 1998 (D3-0001-98-03). These orders were superseded by and Order dated March 11, 1999 (D3-0001-99-01). The Orders obligate O&R to implement a full remedial program.

SECTION 6: SITE CONTAMINATION

6.1: Summary of the Remedial Investigation

A Remedial Investigation (RI) has been conducted. The purpose of the RI was to define the nature and extent of any contamination resulting from previous activities at the site. The field activities and findings of the investigation are described in the RI Report.

The following general activities are conducted during an RI:

- Research of historical information,
- Geophysical survey to determine the lateral extent of wastes,
- Test pits, soil borings, and monitoring well installations,
- Sampling of waste, surface and subsurface soils, groundwater, and soil vapor,
- Sampling of surface water and sediment,
- Ecological and Human Health Exposure Assessments.

The analytical data collected on this site includes data for:

- air
- groundwater
- soil
- soil vapor
- indoor air

6.1.1: Standards, Criteria, and Guidance (SCGs)

The remedy must conform to promulgated standards and criteria that are directly applicable or that are relevant and appropriate. The selection of a remedy must also take into consideration guidance, as appropriate. Standards, Criteria and Guidance are hereafter called SCGs.

To determine whether the contaminants identified in various media are present at levels of concern, the data from the RI were compared to media-specific SCGs. The Department has developed SCGs for groundwater, surface water, sediments, and soil. The NYSDOH has developed SCGs for drinking water and soil vapor intrusion. The tables found in Exhibit A list the applicable SCGs in the footnotes. For a full listing of all SCGs see: http://www.dec.ny.gov/regulations/61794.html

6.1.2: RI Results

The data have identified contaminants of concern. A "contaminant of concern" is a hazardous waste that is sufficiently present in frequency and concentration in the environment to require evaluation for remedial action. Not all contaminants identified on the property are contaminants of concern. The nature and extent of contamination and environmental media requiring action are summarized in Exhibit A. Additionally, the RI Report contains a full discussion of the data. The contaminant(s) of concern identified for this Operable Unit at this site is/are:

COAL TAR	Chrysene
BENZENE	FLUORANTHENE
TOLUENE	FLUORENE
ETHYLBENZENE	indeno(1,2,3-cd)pyrene
XYLENE (MIXED)	BENZO(A)PYRENE
NAPHTHALENE	BENZO(GHI)PERYLENE
ANTHRACENE	DIBENZ[A,H]ANTHRACENE
ACENAPHTHENE	PHENANTHRENE
BENZO[K]FLUORANTHENE	PYRENE

As illustrated in Exhibit A, the contaminant(s) of concern exceed the applicable SCGs for:

- groundwater
- soil

6.2: Interim Remedial Measures

An interim remedial measure (IRM) is conducted at a site when a source of contamination or exposure pathway can be effectively addressed before issuance of the Record of Decision.

There were no IRMs performed at this site during the RI.

6.3: Summary of Environmental Assessment

This section summarizes the assessment of existing and potential future environmental impacts presented by the site. Environmental impacts may include existing and potential future exposure pathways to fish and wildlife receptors, wetlands, groundwater resources, and surface water.

The Fish and Wildlife Resources Impact Analysis (FWRIA) for OU 02, which is included in the RI report, presents a detailed discussion of the existing and potential impacts from the site to fish and wildlife receptors.

OU1 – The primary contaminants of concern are found in coal tar that was the by-product from the operation of the former MGP. Site investigations revealed that both soil and groundwater are contaminated with volatile and semi-volatile organic compounds exceeding SCGs mainly at depth throughout the site. Non-aqueous phase liquids (NAPL) were found in soil at depths ranging from 6 to 22 feet below ground surface (bgs) on-site.

OU2- Site investigations indicated that coal tar has migrated off-site or was directly discharged onto OU2 resulting in both soil and groundwater contamination. As in OU1, contaminants of concern at OU2 include volatile and semi-volatile organic compounds and are found at concentrations exceeding SCGs. NAPL saturated soil was found at depths ranging from 10 to 20 feet bgs.

OU3 – The remedial investigation conducted at the site indicates that sediments in the Hudson River embayment adjacent the site have been impacted by contaminants resulting from the operation of the former MGP. Analytical results from sediment samples obtained near the mouth of the storm water outfall discharging into the embayment have shown MGP related impacts. The nature and extent of the impacts detected will be further evaluated during the remedy selection phase for OU3 portion of the site.

The site presents a significant environmental threat due to the ongoing releases of contaminants from source areas (NAPL contaminated soils) into groundwater.

6.4: <u>Summary of Human Exposure Pathways</u>

This human exposure assessment identifies ways in which people may be exposed to site-related contaminants. Chemicals can enter the body through three major pathways (breathing, touching or swallowing). This is referred to as *exposure.*

Operable Unit 1 (OU-1) - The site is completely fenced, which restricts public access. However, persons who enter the site could contact contaminants if they were to dig or otherwise disturb the soil located beneath the gravel cover material. People are not drinking the contaminated groundwater because the area is served by a public water supply that is not affected by this contamination. Volatile organic compounds in the groundwater may move into the soil vapor (air spaces within the soil), which in turn may move into overlying buildings and affect the indoor air quality. This process, which is similar to the movement of radon gas from the subsurface into the indoor air of buildings, is referred to as soil vapor intrusion. Because there is no on-site building, inhalation of site contaminants in indoor air due to soil vapor intrusion does not represent a concern for the site in its current condition. The potential exists for the inhalation of site contaminants due to soil vapor intrusion for any future on-site development and occupancy.

Operable Unit 2 (OU-2) - Contact with contaminated soil or groundwater is unlikely unless people dig below the ground surface. People are not drinking the contaminated groundwater because the area is served by a public water supply that is not affected by this contamination. Sampling indicates soil vapor intrusion is not a concern for buildings in OU-2.

Operable Unit 3 (OU-3) - The potential exists for people to come in contact with contaminants in the shallow river sediments while entering or exiting the river during recreational activities.

6.5: Summary of the Remediation Objectives

The objectives for the remedial program have been established through the remedy selection process stated in 6 NYCRR Part 375. The goal for the remedial program is to restore the site to pre-disposal conditions to the extent feasible. At a minimum, the remedy shall eliminate or mitigate all significant threats to public health and the environment presented by the contamination identified at the site through the proper application of scientific and engineering principles.

The remedial action objectives for this site are:

Groundwater

RAOs for Public Health Protection

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.

RAOs for Environmental Protection

- Prevent the discharge of contaminants to surface water.
- Remove the source of ground or surface water contamination.

Soil

RAOs for Public Health Protection

- Prevent ingestion/direct contact with contaminated soil.

RAOs for Environmental Protection

- Prevent migration of contaminants that would result in groundwater or surface water contamination.

Soil Vapor

RAOs for Public Health Protection

- Mitigate impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a site.

SECTION 7: SUMMARY OF THE SELECTED REMEDY

To be selected the remedy must be protective of human health and the environment, be cost-effective, comply with other statutory requirements, and utilize permanent solutions, alternative technologies or resource recovery technologies to the maximum extent practicable. The remedy must also attain the remedial action objectives identified for the site, which are presented in Section 6.5. Potential remedial alternatives for the Site were identified, screened and evaluated in the feasibility study (FS) report.

A summary of the remedial alternatives that were considered for this site is presented in Exhibit B. Cost information is presented in the form of present worth, which represents the amount of money invested in the current year that would be sufficient to cover all present and future costs associated with the alternative. This enables the costs of remedial alternatives to be compared on a common basis. As a convention, a time frame of 30 years is used to evaluate present worth costs for alternatives with an indefinite duration. This does not imply that operation, maintenance, or monitoring would cease after 30 years if remediation goals are not achieved. A summary of the Remedial Alternatives Costs is included as Exhibit C.

The basis for the Department's remedy is set forth at Exhibit D.

The selected remedy is referred to as the Soil Removal remedy.

The estimated present worth cost to implement the remedy is $27,500,000. The cost to construct the remedy is estimated to be $27,200,000 and the estimated average annual cost is $17,200.

The elements of the selected remedy are as follows:

1) A remedial design program will be implemented to provide the details necessary for the construction, operation, maintenance, and monitoring of the remedial program. Notably a pre-design investigation will be performed to determine the depth and extent of excavation for those properties which were not fully delineated during the RI. Green remediation principles and techniques will be implemented to the extent feasible in the design, implementation, and site management of the remedy as per DER-31. The major green remediation components are as follows:
a) Considering the environmental impacts of treatment technologies and remedy stewardship over the long term;
b) Reducing direct and indirect greenhouse gas and other emissions;
c) Increasing energy efficiency and minimizing use of non-renewable energy;
d) Conserving and efficiently managing resources and materials;
e) Reducing waste, increasing recycling and increasing reuse of materials which would otherwise be considered a waste;
f) Maximizing habitat value and creating habitat when possible;
g) Fostering green and healthy communities and working landscapes which balance ecological, economic and social goals; and
h) Integrating the remedy with the end use where possible and encouraging green and sustainable re-development.

2) Excavation and off-site disposal of MGP impacted soil at properties located on West Street, 111-117 Maple Avenue; the Apartment Complex and the alleyway. Soil cleanup objectives (SCOs) to allow the residential use of the site will guide the excavation of contaminated soils with the exception of use of the site-specific SCO for total PAHs of 25 ppm based on background conditions. Approximately 30,000 cubic yards of soil will be removed and sent off site for disposal at a permitted facility. Clean fill meeting the requirements of 6 NYCRR Part 375-6.7d will be brought in to replace the excavated soil. No demolition of occupied buildings is anticipated.

3) The existing buildings and pavement at the site will form a portion of the site cover. Where there will be exposed surface soil, a site cover will be maintained as a component of any future site development, which will consist either of the structures such as buildings, pavement, sidewalks comprising the site development or a soil cover in areas where the upper two feet of exposed surface soil will exceed the applicable soil cleanup objectives (SCOs). Where the soil

cover is required it will be a minimum of two feet of soil, meeting the SCOs for cover material as set forth in 6 NYCRR Part 375-6.7(d) for restricted residential use. The soil cover will be placed over a demarcation layer, with the upper six inches of the soil of sufficient quality to maintain a vegetation layer. Any fill material brought to the site will meet the requirements for the identified site use as set forth in 6 NYCRR Part 375-6.7(d).

4) A barrier will be in place in those areas where the excavation will not be completed beneath the existing structures to prevent recontamination of the remediated areas by contamination remaining under the buildings. The type of barrier will be determined during the design phase of the project.

5) Excavation activities will occur in the immediate vicinity of an existing stormwater drainage line to remove contaminated soil around or within the beddings of the drainage line. The need to protect or relocate the line to allow the necessary excavation will be determined during the design phase of the project, provided contaminated materials are addressed consistent with the remedial objectives and subject to field verification by the Department's on-site representative during construction.

6) Odor, noise and dust control measures including the use of a temporary structure (to the extent practicable) will be implemented during excavation to limit the impacts of remedial activities on the public. Groundwater extracted during construction will be sent off-site for treatment and disposal or treated on-site and discharged in compliance with applicable discharge standards

7) Following the excavation, if determined necessary, the remaining impacted site groundwater will be treated using an in-situ treatment technique to enhance natural attenuation. An oxygen injection system is currently being considered, with the final determination of the in-situ groundwater treatment to be made during the design phase of the project.

8) The site management plan (SMP) required for OU1 of the site will be developed and implemented to incorporate the OU2 remedy. The SMP will identify the institutional controls and engineering controls (IC/ECs) required for the remedy and detail their implementation. The plan will include, but may not be limited to:

a. an Engineering Control Plan that identifies all use restrictions and engineering controls for the site and details the steps and media-specific requirements necessary to ensure the following institutional and/or engineering controls remain in place and effective:

Engineering Controls: A site cover currently exists on the northern portion of OU2 and consists of buildings, pavement, sidewalks and landscaped areas. This cover will be maintained to allow for residential use of the site. Any site redevelopment will require remedial action in this area (see bullet 9 below). This plan includes, but may not be limited to:

i. Excavation Plan which details the provisions for management of future excavation in areas of remaining contamination;

ii. provisions for the management and inspection of the identified engineering controls and groundwater use controls;

iii. a groundwater monitoring plan to assess the performance and effectiveness of the remedy.

iv. a schedule of monitoring and frequency of submittals to the Department; and

9) Areas of subsurface contamination have been determined to currently be inaccessible due to the presence of buildings/structures, an unknown quantity of impacted material will remain in the front and under the existing buildings which may need to be addressed at a future point in time to complete this remedy. The impacted material will be subject to further characterization and removal and/or treatment, should the demolition of the buildings occur as part of a future redevelopment of this area.

Exhibit A

Nature and Extent of Contamination

This section describes the findings of the Remedial Investigation for all environmental media that were evaluated. As described in Section 6.1, samples were collected from various environmental media to characterize the nature and extent of contamination.

For each medium, a table summarizes the findings of the investigation. The tables present the range of contamination found at the site in the media and compares the data with the applicable SCGs for the site. The contaminants are arranged into two categories: volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). For comparison purposes, the SCGs are provided for each medium that allows for unrestricted use. For soil, if applicable, the Restricted Use SCGs identified in Section 6.1.1 are also presented.

Waste/Source Areas

As described in the RI report, waste/source materials were identified at the OU-2 portion of the site and are impacting groundwater, soil, and potentially surface water and sediment in the Hudson River embayment.

Wastes are defined in 6 NYCRR Part 375-1.2 (aw) and include solid, industrial and/or hazardous wastes. Source Areas are defined in 6 NYCRR Part 375 (au). Source areas are areas of concern at a site were substantial quantities of contaminants are found which can migrate and release significant levels of contaminants to another environmental medium. Wastes and Source areas were identified at the site.

Manufactured gas was cooled and purified prior to distribution. Two principal waste materials were produced in this process: coal tar and purifier waste. Coal tar is a reddish brown to black oily liquid by-product which formed as a condensate as the gas cooled. Purifier waste is a mixture of iron filings and wood chips which was used to filter and remove cyanide and sulfur gases from the mix prior to distribution.

Coal tar does not readily dissolve in water. Materials such as this are commonly referred to as non-aqueous phase liquid, or NAPL. The term NAPL and coal tar are used interchangeably in this document. Although most coal tars are slightly denser than water, the difference in density is slight. Consequently, they can either float or sink when in contact with water.

Specific volatile organic compounds (VOCs) of concern are benzene, toluene, ethylbenzene and xylenes. These are referred to collectively as BTEX in this document. Specific semivolatile organic compounds of concern are the polycyclic aromatic hydrocarbons (PAHs):

acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
benzo(g,h,i)perylene
benzo(k)fluoranthene
chrysene
dibenzo(a,h)anthracene
fluoranthene
fluorene
indeno(1,2,3-cd)pyrene
2-methylnaphthalene
naphthalene
phenanthrene
pyrene

Total PAH concentrations as referred to in this plan are the sum of the individual PAHs listed above. The italicized PAHs are probable human carcinogens.

Source areas were identified at the site as noted on Figure 3. Coal tar was found at depths ranging from 10 to 20feet below the ground surface.

The waste/source areas identified will be addressed in the remedy selection process.

Groundwater

Groundwater samples were collected from monitoring wells and analyzed for volatile, semivolatile, and metals compounds to assess the nature and extent of groundwater impacts at OU2 resulting from the operation of the former MGP. The primary contaminants of concerns are benzene, ethylbenzene, toluene and xylene (collectively refer to as BTEX) and polycyclic aromatic hydrocarbon (PAH) compounds. The results indicate that groundwater contamination exceeds the SCGs for BTEX and PAH compounds. BTEX compounds were detected at concentrations ranging from non detect to approximately 898 parts per billion (ppb) while PAHs were found at concentrations ranging from non detect to approximately 9,630 ppb. Dense non-aqueous phase liquid (DNAPL) was detected at several monitoring wells located in the northwest portion of the site near the properties on West Street. Site related impacts do not appear to have significantly affected groundwater quality beyond the OU2 boundaries as shown in Figures 1 and 2. Metals were determined not to be contaminants of concern in groundwater. Groundwater is not used as a potable water supply locally as the surrounding area is served by public water.

Table 1 - Groundwater

Detected Constituents	Concentration Range Detected (ppb)[a]	SCG[b] (ppb)	Frequency Exceeding SCG
VOCs			
Benzene	2.4-320	1	6 of 15
Toluene	0.5-18	5	1 of 15
Ethylbenzene	9.4-3.50	5	5 of 15
Xylene, Total	11-210	5	5 of 15
VinylChloride	0-7.0	2	1 of 15
SVOCs			
Acenaphthene	7.3-310	20	15
Fluorene	0.7-59	50	1 of 15
Naphthalene	0.8-9200	10	6 of 15
Phenanthrene	0.3-64	50	1 of 15

a - ppb: parts per billion, which is equivalent to micrograms per liter, ug/L, in water.
b- SCG: Standard Criteria or Guidance - Ambient Water Quality Standards and Guidance Values (TOGs 1.1.1), 6 NYCRR Part 703, Surface water and Groundwater Quality Standards, and Part 5 of the New York State Sanitary Code (10 NYCRR Part 5).

Based on the findings of the RI, the past disposal of hazardous waste has resulted in the contamination of groundwater. The site contaminants that are considered to be the primary contaminants of concern which will drive the remediation of groundwater to be addressed by the remedy selection process are: BTEX and PAHs related to MGP coal tar.

Soil

Subsurface soil samples were collected and analyzed for volatile, semivolatile, and metals compounds at the OU2 study area during the RI to determine the nature and extent of impacts to soil, as a result of the operation of the former MGP. Subsurface soil impacts exceeding SCOs were detected across the study areas in OU2 and they were encountered at depths ranging from 7 to 25 feet below ground surface (bgs). Subsurface soil contamination was limited to properties between West Street and Maple Avenue. Total PAHs and BTEX contamination was detected at concentrations ranging from non detect to approximately 40,000 and 1,100 ppm, respectively. The highest concentration of PAHs was detected in a soil boring located in the northwest portion of the site, behind the apartment complex. Source material impacts were encountered primarily in the former pond area, currently the rear parking areas for the residences. The nature and extent of soil contamination at OU2 is depicted in Figure 2. Table 2 shows a summary of soil contamination for each class of compounds of concern.

Table 2 - Soil

Detected Constituents	Concentration Range Detected (ppm)[a]	Unrestricted SCG[b] (ppm)	Frequency Exceeding Unrestricted SCG	Residential SCG[c] or Protection of Groundwater SCG[d] (ppm)	Frequency Exceeding Residential SCG
VOCs					
Benzene	.0007-170	0.06	12 of 68	0.06[d]	12 of 68
Toluene	.0004-29	0.7	8 of 68	0.7[d]	8 of 68
Ethylbenzene	.0008-520	1	17 of 68	1[d]	17 of 68
Xylene, Total	.0017-410	0.26	22of 68	100 (1.6[d])	4 of 68
Acetone	.016-.21	0.05	21 of 68	0.05[d]	21 of 68
Methylene chloride	.0022-.053	0.05	1 of 68	51	0 of 68
SVOCs					
Acenaphthene	.012-3200	20	14 of 68	100	7 of 68
Acenaphthylene	.021-280	100	2 of 68	100	2 of 68
Anthracene	.016-3000	100	7 of 68	100	7 of 68
Benzo[g,h,i]perylene	.016-270	100	3 of 68	100	3 of 68
Fluoranthene	.01-1900	100	9 of 68	100	9 of 68
Fluorene	.02-1300	30	11 of 68	100	6 of 68

Detected Constituents	Concentration Range Detected (ppm)[a]	Unrestricted SCG[b] (ppm)	Frequency Exceeding Unrestricted SCG	Residential SCG[c] or Protection of Groundwater SCG[d] (ppm)	Frequency Exceeding Residential SCG
Naphthalene	.01-7000	12	18 of 68	12[d]	18 of 68
Phenanthrene	.0096-5600	100	13 of 68	100	13 of 68
Pyrene	.021-2500	100	11 of 68	100	11 of 68
Benz[a]anthracene	.011-760	1	29 of 68	1	29 of 68
Benzo[a]pyrene	.015-660	1	29 of 68	1	29 of 68
Benzo[b]fluoranthene	.01-220	1	27 of 68	1	27 of 68
Benzo[k]fluoranthene	.017-540	0.8	30 of 68	1	30 of 68
Chrysene	.011-930	1	28 of 68	1	28 of 68
Dibenz[a,h]anthracene	.016-45	0.33	18 of 68	0.33	18 of 68
Indeno[1,2,3-cd]pyrene	.014-190	0.5	26 of 68	0.5	26 of 68

a - ppm: parts per million, which is equivalent to milligrams per kilogram, mg/kg, in soil;
b - SCG: Part 375-6.8(a), Unrestricted Soil Cleanup Objectives.
c - SCG: Part 375-6.8(b), Restricted Use Soil Cleanup Objectives for the Protection of Public Health for Residential Use, unless otherwise noted.
d - SCG: Part 375-6.8(b), Restricted Use Soil Cleanup Objectives for the Protection of Groundwater.

Based on the findings of the Remedial Investigation, the presence of MGP related contamination including DNAPL has resulted in the contamination of soil. The site contaminants identified in soil which are considered to be the primary contaminants of concern, to be addressed by the remedy selection process are, polycyclic aromatic hydrocarbons (PAHs) and benzene, toluene, ethylbenzene and xylene (BTEX) compounds associated with residues from the operation of the former MGP.

Surface soil samples were not collected at OU2 as most of the area is covered with buildings and pavement.

Based on the findings of the Remedial Investigation, the past disposal of hazardous waste has resulted in the contamination of soil. The site contaminants identified in soil which are considered to be the primary contaminants of concern, to be addressed by the remedy selection process are BTEX and PAHs related to MGP coal tar. To the extent surface soil has been impacted by past disposal practices, this contamination will be addressed in conjunction with the remediation of the identified subsurface contamination.

Surface Water and Sediments

Sediment samples collected from the Hudson River embayment revealed elevated levels of PAHs. The nature and extent of the detected impacts will be determined and addressed as part of the OU3 remedial program. There is no evidence of surface water impacts based on the RI results.

Soil Vapor

The evaluation of the potential for soil vapor intrusion resulting from the presence of site related soil or groundwater contamination was evaluated by the sampling of soil vapor, sub-slab soil vapor under structures, and indoor air inside structures. At this site due to the presence of buildings in the impacted area a full suite of samples were collected to evaluate whether soil vapor intrusion was occurring.

Soil vapor samples were collected from the sub-slab of several residential properties located on the OU2 portion of the site. Indoor air and outdoor air samples were also collected at this time. The samples were collected to determine whether actions are needed to address exposures related to soil vapor intrusion.

Based on the concentration detected, and in comparison with the NYSDOH Soil Vapor Intrusion Guidance,
no site-related soil vapor contamination of concern was identified during the RI. Therefore, no remedial alternatives need to be evaluated for soil vapor.

Exhibit B

Description of Remedial Alternatives

The following alternatives were considered based on the remedial action objectives (see Section 6.5) to address the contaminated media identified at the site as described in Exhibit A.

Alternative 1: No Action

The No Action Alternative is evaluated as a procedural requirement and as a basis for comparison. This alternative leaves the site in its present condition and does not provide any additional protection to public health and the environment. The No Action alternative does not include long-term monitoring and therefore has no associated cost.

Alternative 2: NAPL Recovery, In-Situ Groundwater Treatment and Natural Attenuation (NA)

This Alternative will include:

- NAPL recovery from the areas containing recoverable NAPL;
- maintenance of existing paved areas to prevent contact and act as low-permeability soil cover to limit infiltration of precipitation in the most impacted areas;
- in-situ treatment such as oxygen injection and NA to address groundwater impacts; and
- development of a site management plan to include engineering controls to prevent exposure to impacted subsurface soil and groundwater.

The cost to implement Alternative 2, based on an annual operation and maintenance (O&M), for a period of 30 years has been estimated as follows:

Present Worth: .... $ 2,086,000
Capital Cost: $1,125,000
Annual Costs: .... $ 62,500

Alternative 3: NAPL Recovery, Phased Soil Excavation, Barrier Installation, In-situ Groundwater Treatment and NA

This alternative provides for all the requirements of Alternative 2 plus phased soil removal and soil cleanup to Part 375 Residential or Restricted Residential SCOs. This alternative will include options that will be implemented in two phases.

Phase 1 will include:

- NAPL recovery as described in Alternative 2 and will be continued until a future demolition of the apartment complex would allow for the soil excavation as described in Phase 2;
- excavation of contaminated soil exceeding Part 375 Residential SCOs at the West Street properties to depths ranging from 15 to 17 feet bgs;
- installation of a barrier to prevent recontamination of the area adjacent source material present in the apartment complex;
- backfill of the excavated areas with clean soil to bring the site to design grade;
- groundwater monitoring following Phase 1 to document groundwater conditions prior to Phase 2; and

- development of a site management to include institutional and engineering controls to prevent exposure to impacted subsurface soil and groundwater.

Phase 2 will include the following actions to be taken in the future should demolition of the existing buildings located at 111-117 Maple Avenue and the apartment complex parcels occur:

- excavation of contaminated soil exceeding Part 375 Restricted Residential SCOs or background levels to a maximum depth of 15 feet bgs for the Apartment Complex property;
- excavation of contaminated soil exceeding Part 375 Residential SCOs or background levels for the 111-117 Maple Avenue properties to a maximum depth of 15 feet bgs;
- NA and in-situ groundwater treatment, if determined necessary; and
- the site management plan would also include engineering controls on groundwater use.

The cost to implement Alternative 3, based on an annual operation and maintenance (O&M), for a period of 30 years has been estimated as follows:

Present Worth: .... $ 17,297,000
Capital Cost:... $ 16,725,000
Annual Costs:.. $ 37,200

Alternative 4: NAPL Recovery, Phased Removal to Part 375 Residential/Restricted Residential SCOs and Source Area Removal in Phase 1 and In-situ Groundwater Treatment and NA

This alternative has the same components as in Alternative 3 but will include additional excavation in the areas near and within the MW-32S NAPL location thereby eliminating the need for the installation of a barrier wall to prevent recontamination of cleaned areas. Specific components of this alternative will include:

Phase 1:

- NAPL recovery as described in Alternative 2 and will be continued until a future demolition of the apartment complex would allow for the soil excavation as described in Phase 2;
- excavation of contaminated soil exceeding Part 375 Residential SCOs or background levels to a maximum depth ranging from 15 to 17 feet bgs for single family residences located on West Street;
- soil removal in the vicinity of MW-32S containing NAPL and soil within this area exceeding Part 375 Restricted Residential SCOs or background levels to eliminate the potential for recontamination of the adjacent excavated areas;
- groundwater monitoring; and
- development of a site management to include engineering controls to prevent exposure o impacted subsurface soil and groundwater.

Phase 2 will include the following actions to be taken in the future should demolition of the existing buildings located at 111-117 Maple Avenue and the apartment complex parcels occur:

- excavation of contaminated soil from the apartment complex and properties located at 111-117 Maple Avenue for soil exceeding Part 375 Residential SCOs or background levels to a maximum depth of 15 feet bgs;
- NA and in-situ treatment of groundwater, if determined necessary; and

- development of a site management to include institutional and engineering controls to prevent exposure to impacted subsurface soil and groundwater.

The cost to implement Alternative 4, based on an annual operation and maintenance (O&M), for a period of 30 years has been estimated as follows:

Present Worth: .... $ 20,406,000
Capital Cost:... $19,700,000
Annual Costs:.. $45,900

Alternative 5: Phased Soil Removal to Part 375 Residential Levels, Barrier Installation and Groundwater Treatment

This alternative has been modified from the FS and will include soil removal as close as possible to the existing buildings to meet Residential SCOs. Non-accessible material will be removed in a second phase, subject to future building demolition.

Phase 1 will include:

- excavation of contaminated soil exceeding Part 375 Residential SCOs or the established background value for total PAHs of 25 ppm in the areas identified on Figure 3, including the single family properties located on West Street, town houses located on 111 to 117 Maple Avenue, and the apartment complex and alleyway between West Street and Maple Avenue to depths up to 17 feet bgs;
- backfill of excavated areas with clean soil meeting Part 375 residential SCOs from an off-site location to establish the design grade at the site;
- installation of a barrier in select areas as needed to prevent recontamination of the remediated areas. The type of barrier will be determined during the design phase;
- protection, temporary bypass, or removal/replacement of the 54 inch stormwater pipe present in the alleyway and apartment complex;
- groundwater monitoring to assess the effectiveness of the remedy; and
- development of a site management to include appropriate engineering controls to prevent exposure to impacted subsurface soil (e.g. soil remaining in front and under the buildings).

Phase 2 will include the following actions to be taken in the future, should demolition of the existing buildings located at 111-117 Maple Avenue and the Apartment Complex parcels occur:

- excavation of contaminated soil in the front, under and adjacent to the apartment complex and properties located at 111-117 Maple Avenue for soil exceeding Part 375 Residential SCOs or background levels;
- the depth and method of excavation, including the installation of any temporary excavation support, will be established after a focused investigation is complete to determine the lateral and vertical extent of impacted material in the front, under and adjacent to the buildings; and
- NA and groundwater treatment using in-situ treatment technology such as oxygenation, if determined necessary;

The cost to implement Alternative 5, based on an annual operation and maintenance (O&M), for a period of 30 years has been estimated as follows:

Present Worth: .... $ 27,500,000
Capital Cost:.. $27,200,000
Annual Costs:.. $17,200

Alternative 6: In-Situ Solidification (ISS) of Source Materials and Soil removal in Non-ISS Areas.

This Alternative will address the impacted soil by using ISS instead of excavation of accessible source material on the apartment complex parcel and on the Alleyway.

Alternative 6 will include the following components:

- perform ISS in the source areas to depths ranging from approximately 15 to 17 feet bgs. Prior to ISS, the materials located at the top 5 feet in the ISS area will be excavated or pre-cut to remove below grade obstructions;
- demolition and temporary bypass of the 54 inch stormwater pipe;
- excavation of contaminated soil exceeding Part 375 Residential SCOs or background levels to a maximum depth ranging from 15 to 17 feet bgs for single family residences located on West Street ;
- installation of a storm drain utility corridor through the ISS mass to facilitate the reinstallation of a new 54 inch storm line and its branches. The utility corridor will be backfilled with clean fill to prevent future contact with solidified material by construction workers performing maintenance on the storm drain system;
- installation of a minimum 2 feet of clean soil cover over the entire ISS area;
- groundwater monitoring to determine the effectiveness of the proposed remedy;
- development of a site management to include engineering controls to prevent exposure to impacted subsurface soil and groundwater.

Phase 2 will include the following actions to be taken in the future should demolition of the existing buildings located at 111-117 Maple Avenue and the apartment complex parcels occur:

- future excavations of impacted materials beneath and adjacent to the apartment complex buildings if and when the apartment complex is demolished in the future. The depth of excavation will be established after a focused investigation is complete to determine the lateral and vertical extent of impacted material at the parcels; and
- groundwater treatment using in-situ treatment technology such as oxygenation and natural attenuation

The cost to implement Alternative 6, based on an annual operation and maintenance (O&M), for a period of 30 years has been estimated as follows:

Present Worth: $19,664,000
Capital Cost:.. $19, 400,000
Annual Costs:.. $17,200

Alternative 7: Restoration to Unrestricted Conditions

This alternative achieves all of the SCGs discussed in Section 6.1.1 and Exhibit A and soil meets the unrestricted soil cleanup objectives listed in Part 375-6.8 (a). This alternative would include: excavation and off-site disposal of all waste and soil contamination above the unrestricted soil cleanup objectives. The remedy will not rely on institutional or engineering controls to prevent future exposure. There is no Site Management, no restrictions, and no periodic review. This remedy will have no annual cost, only the capital cost.

This alternative will include excavation of soil exceeding the Part 375 Unrestricted SCOs or background levels in the OU2 area to predisposal condition and will require the demolition of the Apartment Complex and the building at 111-117 Maple Avenue. The components of this alternative will include the following:

- acquisition and demolition of buildings currently located at OU2;
- excavation of contaminated soil exceeding Part 375 Unrestricted SCOs or background levels to a depth of approximately 15 to 17 feet bgs. Approximately 90,000 cubic yards of impacted material will be removed for treatment and/disposal at an off-site permitted facility;
- excavation will be conducted within a temporary fabric structure (to the extent practicable) to control odor, vapor and dust; and
- backfilling the excavated areas with certified clean soil from an off-site location. The site will be restored to a pre-disturbance grade.

The cost to implement Alternative 7 has been estimated as follows:

Present Worth: $42,000,000
Capital Cost: $42,000,000
Annual Costs: $0

Exhibit C

Remedial Alternative Costs

Remedial Alternative	Capital Cost ($)	Annual Costs ($)	Total Present Worth ($)
No Action	0	0	0
Alternative 2: NAPL Recovery and In-Situ Groundwater Treatment / NA	$1,125,000	$62,500	$2,086,000
Alternative 3: NAPL Recovery and Phased Soil Excavation with In-situ Groundwater Treatment and NA	$16,725,000	$37,200	$17,297,000
Alternative 4: NAPL Recovery, Phased Removal to Part 375 Residential/Restricted Residential Levels and Removal of the MW-32S Area in Phase 1, with In-situ Groundwater Treatment and NA	$19,700,000	$45,900	$20,406,000
Alternative 5: Phased Soil Removal to Part 375 Residential Levels, with Removal of Currently Accessible impacted Material	$27,200,000	$17,200	$27,500,000
Alternative 6: ISS, with Phased Removal to Part 375 Residential Levels in Non-ISS Areas	$19,400,000	$17,200	$19,664,000
Alternative 7: Purchase and Demolition of Buildings followed by Removal of Soil Exceeding Unrestricted Levels	$42,000,000	0	$42,000,000

Exhibit D

SUMMARY OF THE SELECTED REMEDY

The Department has selected Alternative 5, Soil Removal to Part 375 Residential SCO Levels, with Removal of Currently Accessible impacted Material to the extent practicable as the remedy for the OU2 portion of the site. Alternative 5 will achieve the remediation goals for the site by reducing the volume, toxicity and mobility of contaminated soil due to removal and off-site disposal of contaminated material. The selected remedy will greatly reduce the source of contamination to groundwater and will monitor and treat contaminated groundwater using in-situ technology, as required. Given that OU2 portion of the site is zoned for residential use, this alternative has been modified from the FS to allow the site to be remediated to meet residential cleanup objectives by addressing all currently accessible contaminated materials to residential SCOs, taking into account site background levels for PAHs. The original alternative presented in the FS calls for the removal of source material in the initial phase while addressing the remaining impacted soil in the second phase after the buildings have been demolished. The elements of this remedy are described in Section 7. The selected remedy is depicted in Figure 3 and 4.

Basis for Selection

The selected remedy is based on the results of the RI and the evaluation of alternatives. The criteria to which potential remedial alternatives are compared are defined in 6 NYCRR Part 375. A detailed discussion of the evaluation criteria and comparative analysis is included in the FS report.

The first two evaluation criteria are termed "threshold criteria" and must be satisfied in order for an alternative to be considered for selection.

1. Protection of Human Health and the Environment. This criterion is an overall evaluation of each alternative's ability to protect public health and the environment.

Alternative 1 (No Action) does not include active remedial actions and thus will not provide any additional protection to human health and the environment over what currently exists. Additionally, this alternative will not comply with SCGs; since source material will remain in place and continue to pose a threat to both human health and the environment. Alternative 2 (NAPL recovery, in-situ groundwater treatment and NA) will not meet the SCGs nor satisfy the RAOs in a reasonable time. Therefore, Alternatives 1 and 2 are eliminated from further evaluation.

Alternatives 3,4,5,6 and 7 will all provide some level of protection to public health and the environment and were retained for further evaluation.

Alternatives 3 and 4 will provide less protection to the public health and the environment as most of the accessible material will be addressed in the distant future and will not meet residential use SCOs. Alternative 6 will provide a lesser amount of protection to the public health and the environment as some portion of the site will not be addressed to meet residential use SCOs. In addition, the material that has been solidified will remain in place at the site. Alternative 5 will achieve protection by immediate excavation and off-site disposal of all the accessible materials to readily provide for residential use. Alternative 5 will provide permanent reduction of volume of impacted materials due to removal and off-site treatment and/or disposal.

2. Compliance with New York State Standards, Criteria, and Guidance (SCGs). Compliance with SCGs addresses whether a remedy will meet environmental laws, regulations, and other standards and criteria. In addition, this criterion includes the consideration of guidance which the Department has determined to be applicable on a case-specific basis.

Alternatives 3 and 4, which provide for phased implementation of remedy, will meet the SCGs when both phases are implemented. These alternatives will remove MGP source material that may continue to contaminate other media, including groundwater, and will provide soil cover and institutional controls to protect public health. However, Alternatives 3 and 4 will not meet SCOs for residential use as contaminated materials exceeding background levels will be left at depth. In addition, these two alternatives will defer remediation of accessible materials till later phase of remedy implementation. Satisfactory implementation of these alternatives will occur at an unknown time in the future and will depend on when the existing buildings are demolished for redevelopment. Alternative 5 will better achieve the SCGs by removing all currently accessible MGP impacted soil for off-site disposal and/or treatment, thereby eliminating the likelihood of off-site migration of contaminants and limiting exposure. All accessible impacted materials will be removed in the first phase to meet residential use SCOs or established background levels of 25 ppm total PAHs. Under this alternative, groundwater will be actively treated to enhance natural attenuation of groundwater contamination. Alternative 5 will also include a second phase remedial activities to include removal of impacted soil not currently accessible that may be present in the front and under the existing buildings at such time as these buildings are demolished in the future. This alternative will include a site management plan to prevent public exposure to remaining contamination that may be left at depth. Alternative 6 will also achieve these threshold criteria by using a combination of soil excavation and in-place treatment of some other contaminated material using ISS. However, this alternative will only address source material and will not clean the site to residential use levels in all of OU2 area. Some currently accessible material above residential SCO or background levels will be left untreated until sometime in the future. This alternative will provide soil cover and include institutional controls for the protection of public health. Alternative 7 will provide greater protection to human health and the environment by removing all contaminated material from the site. Alternative 7 will meet the threshold criteria and RAOs.

The next six "primary balancing criteria" are used to compare the positive and negative aspects of each of the remedial strategies.

3. Long-term Effectiveness and Permanence. This criterion evaluates the long-term effectiveness of the remedial alternatives after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated: 1) the magnitude of the remaining risks, 2) the adequacy of the engineering and/or institutional controls intended to limit the risk, and 3) the reliability of these controls.

Long-term effectiveness is best achieved by Alternative 7, since nearly all contaminated material will be removed from the site to achieve the unrestricted use SCOs. Alternatives 3 and 4 will provide limited long-term effectiveness only at the completion of both phases of remedy as most of the soil removal is scheduled for implementation in phase 2. Alternative 5 will provide greater long-term effectiveness as the vast majority of impacted material will be removed during the initial phase of remedy implementation. Further removal will occur in the future if and when the existing buildings are demolished. Alternative 6 will provide some long-term effectiveness through ISS treatment of source material in the apartment complex area and removal of contaminated material in the single family properties. The site management will include provisions for Alternatives 5 and 6 to reliably prevent future potential exposures. While Alternative 6 will provide a reasonable level of effectiveness, there are several uncertainties that need resolution. Site investigation indicates that soil stratigraphy in some areas of the target treatment area include a fair amount of peat layers which may prove difficult when in contact with ISS mixtures. In addition, the targeted treatment area is located close to residential properties with limited working areas; as such may pose logistical challenges in terms of limiting impacts to the nearby residences. To be considered for proposal, treatability studies will be necessary and detailed engineering evaluations will need to be performed to determine site specific suitability of this technology at the site and the apartment complex area will need to be cleaned to allow for unrestricted residential use consistent with the current zoning.

4. Reduction of Toxicity, Mobility or Volume. Preference is given to alternatives that permanently and significantly reduce the toxicity, mobility or volume of the wastes at the site.

Alternatives 3 and 4 will provide a reduction in toxicity, mobility and volume. However, this will be achieved when both remedial phases are implemented. Alternative 3 and 4 will address 9,000 and 12,000 cubic yards of source material, respectively during the initial phase of remedy implementation. Alternative 5 will provide reduction in toxicity, mobility and volume as all accessible contaminated material (approximately 30,000 cubic yards) will be removed through excavation to meet residential SCOs or background levels. Contaminated groundwater will be treated in-place under Alternative 5. Alternative 6 will reduce toxicity and mobility of on-site source material by ISS process. Alternative 6 will achieve some level of volume reduction due to the removal of some impacted material to an approved off-site facility for disposal. Alternative 7 will permanently reduce the toxicity, mobility and volume as nearly all contaminated material at the site will be removed for off-site disposal and/or treatment.

5. Short-term Impacts and Effectiveness. The potential short-term adverse impacts of the remedial action upon the community, the workers, and the environment during the construction and/or implementation are evaluated. The length of time needed to achieve the remedial objectives is also estimated and compared against the other alternatives.

Alternatives 3,4,5,6 and 7 will all have short-term impacts to the community and workers due to construction activities. Alternatives 3 and 4 with lesser immediate soil removal will result in the lowest level of short-term impacts compared to the selected alternative. Alternative 5, which will address a greater volume of impacted material will result in fewer impacts to the community compared to Alternatives 6. The best and the most appropriate method of construction to limit impacts to the community will be determined during the design of the selected remedy. Alternative 6 will encapsulate the impacted soil in place through solidification. Given the close proximity of the impacted material to residential properties, Alternative 6 will pose significant construction challenges and will result in greater short-term impact to the community. Alternative 7 with near total removal will result in the highest short-term impacts to the community since extensive excavation will result in a large amount of excavated material to be transported through the community for off-site treatment and/or disposal. In addition, implementation of this alternative will most certainly result in the displacement of residents currently occupying OU2.

Alternatives 3 and 4 will both take approximately four months to complete as most of the impacted materials will be left untreated. Alternatives 5 will be constructed in about 13 months. Alternative 6 will take approximately 12 months to complete. Alternative 7 with near total removal of the impacted materials to pre-disposal condition will take approximately 23 months to complete.

6. Implementability. The technical and administrative feasibility of implementing each alternative are evaluated. Technical feasibility includes the difficulties associated with the construction of the remedy and the ability to monitor its effectiveness. For administrative feasibility, the availability of the necessary personnel

and materials is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, institutional controls, and so forth.

Alternatives 3 and 4 are implementable but will require close coordination with occupants of affected residential properties. Alternatives 5 and 6 are also implementable but with a higher degree of difficulty when compared to Alternatives 3 and 4 due to the greater need to work in close proximity to residential buildings. Alternative 7 is less implementable and complex to perform, since the volume of soil to be excavated under this alternative is significantly higher than the volume of soil to be addressed under the other alternatives. Alternative 7 will require a significant amount of time to implement compared to Alternatives 5 and 6 and will result in displacement of residents and increased truck traffic due to the large volume of material to be transported on local roads for a considerable amount of time. Though Alternative 7 will result in greater reduction in the volume of contaminated soil, it will result in greater short-term disruption to nearby residents during construction, while providing minimal additional protection of human health and the environment compared to the selected alternative.

7. Cost-Effectiveness. Capital costs and annual operation, maintenance, and monitoring costs are estimated for each alternative and compared on a present worth basis. Although cost-effectiveness is the last balancing criterion evaluated, where two or more alternatives have met the requirements of the other criteria, it can be used as the basis for the final decision.

The costs of the alternatives vary significantly, as presented in Exhibit C. Alternatives 3 and 4, while resulting in lower cost for implementation compared to the other alternatives, will provide a lesser degree of protection to human health and the environment as the remedial actions will only address source material while leaving in-place other contaminated material exceeding residential SCOs or background levels. Removal of remaining contamination including source material associated with these alternatives will occur in an unknown time in the future .Alternative 6 though will result in lower cost compared to Alternative 5, but it will not clean the site to allow for residential use, as some impacted material exceeding residential SCOs or background levels will be left in-place. Alternative 7, to unrestricted use, will have the highest present worth cost with a minimal increase in the overall protectiveness of the remedy, over Alternative 5. The incremental cost of over $20 million and significant increase in community disruption and loss of homes associated with Alternative 7 over Alternatives 5 are not justified by the marginal increase in protection.

Alternative 5 while resulting in higher cost of implementation compared to Alternative 6 is the most desirable because it removes most contaminated material for off-site treatment and/or disposal and will meet SCOs for residential use. Also, Alternative 5 will provide the most certainty for remedy implementation compared to Alternative 6.

On the basis of the above evaluations, Alternative 5 offers the most balanced and cost effective remedy without sacrificing protection.

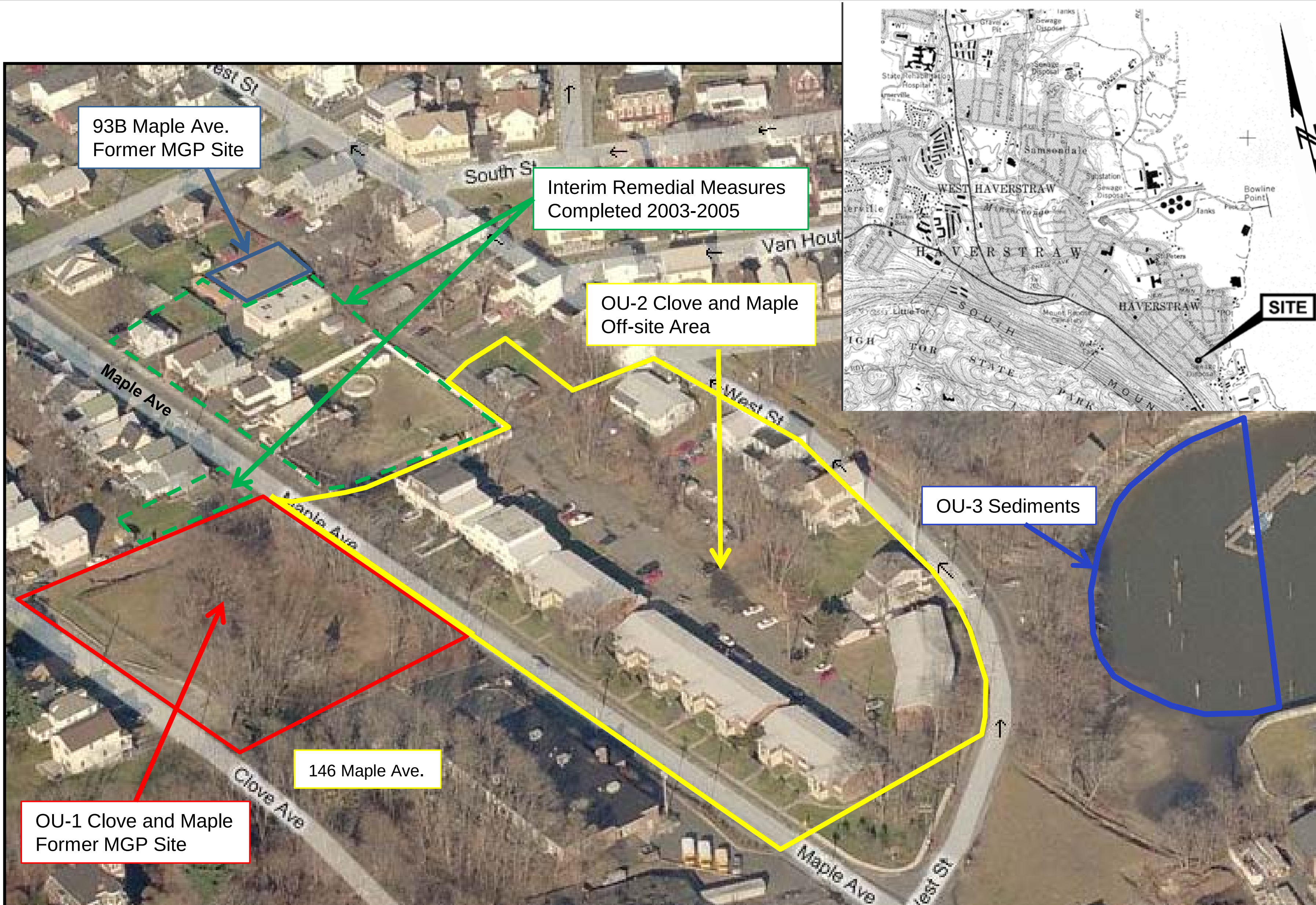
8. Land Use. When cleanup to pre-disposal conditions is determined to be infeasible, the Department may consider the current, intended, and reasonable anticipated future land use of the site and its surroundings in the selection of the soil remedy.

The current, intended, and reasonably anticipated future land use for the OU2 portion of the site is residential. Alternative 7 would achieve the unrestricted SCOs which would allow unrestricted land use of the property consistent with the current zoning. Alternative 5 meets this criterion by removing soil which exceeds the SCOs for residential use and allowing the current use of the apartment complex to continue until the properties are redeveloped in the future. Alternatives 3 and 4 will only meet the land use criterion at a future date when the buildings are removed and the contaminated soil is removed to meet the residential SCOs. Alternative 6 will allow ISS treated soil to remain in the apartment complex area. However, Alternative 6 will not meet the potential future use and current zoning requirement of single family.

The final criterion, Community Acceptance, is considered a "modifying criterion" and is taken into account after evaluating those above. It is evaluated after public comments on the Proposed Remedial Action Plan have been received.

9. Community Acceptance. Concerns of the community regarding the investigation, the evaluation of alternatives, and the PRAP are evaluated. A responsiveness summary has been prepared that describes public comments received and the manner in which the Department will address the concerns raised. If the selected remedy differs significantly from the proposed remedy, notices to the public will be issued describing the differences and reasons for the changes.

Alternative 5 has been selected because, as described above, it satisfies the threshold criteria and provides the best balance of the balancing criterion.

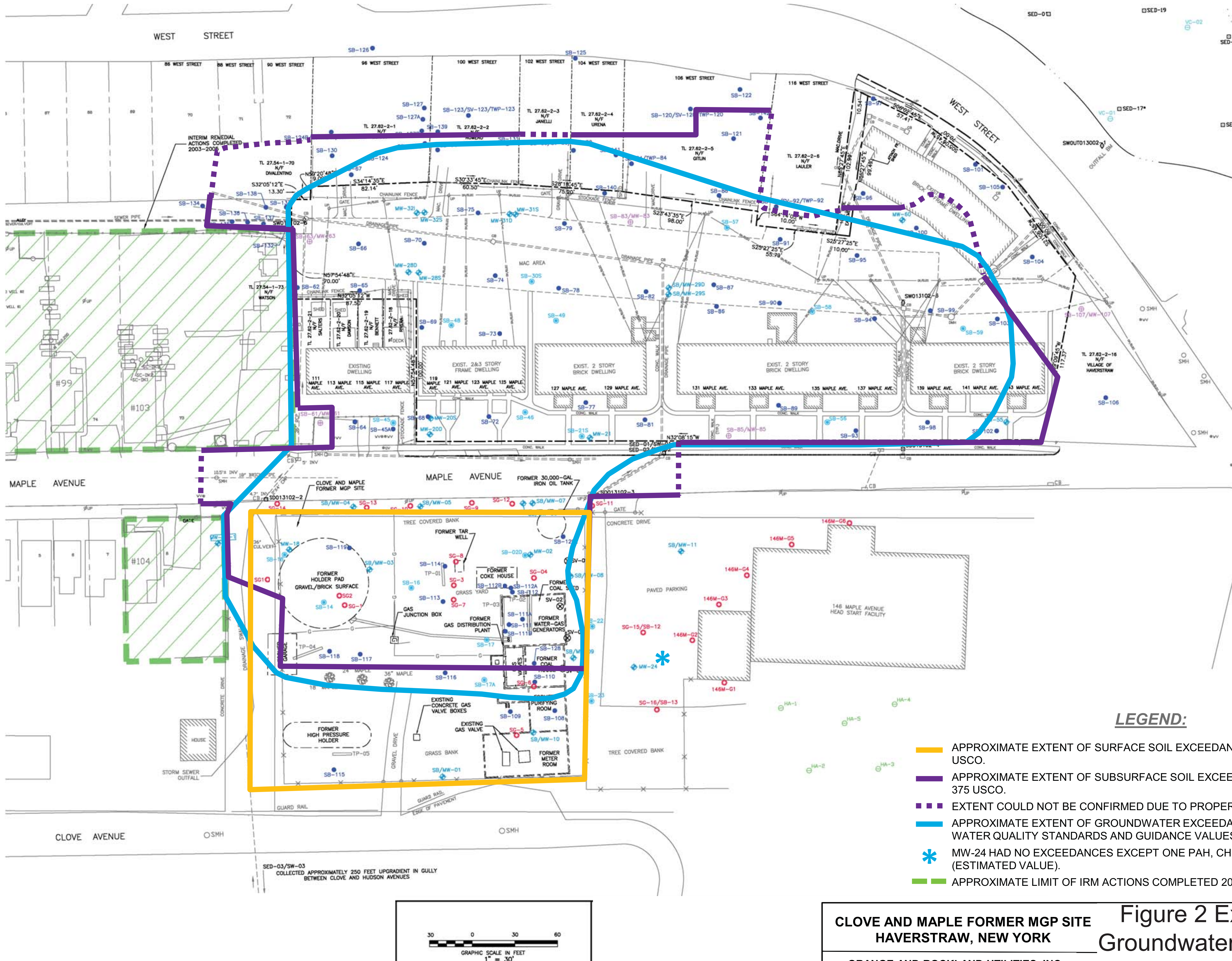


CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

OU-1 AND OU-2
LOCATION AERIAL
PHOTOGRAPH

February 2011 **Figure 1**



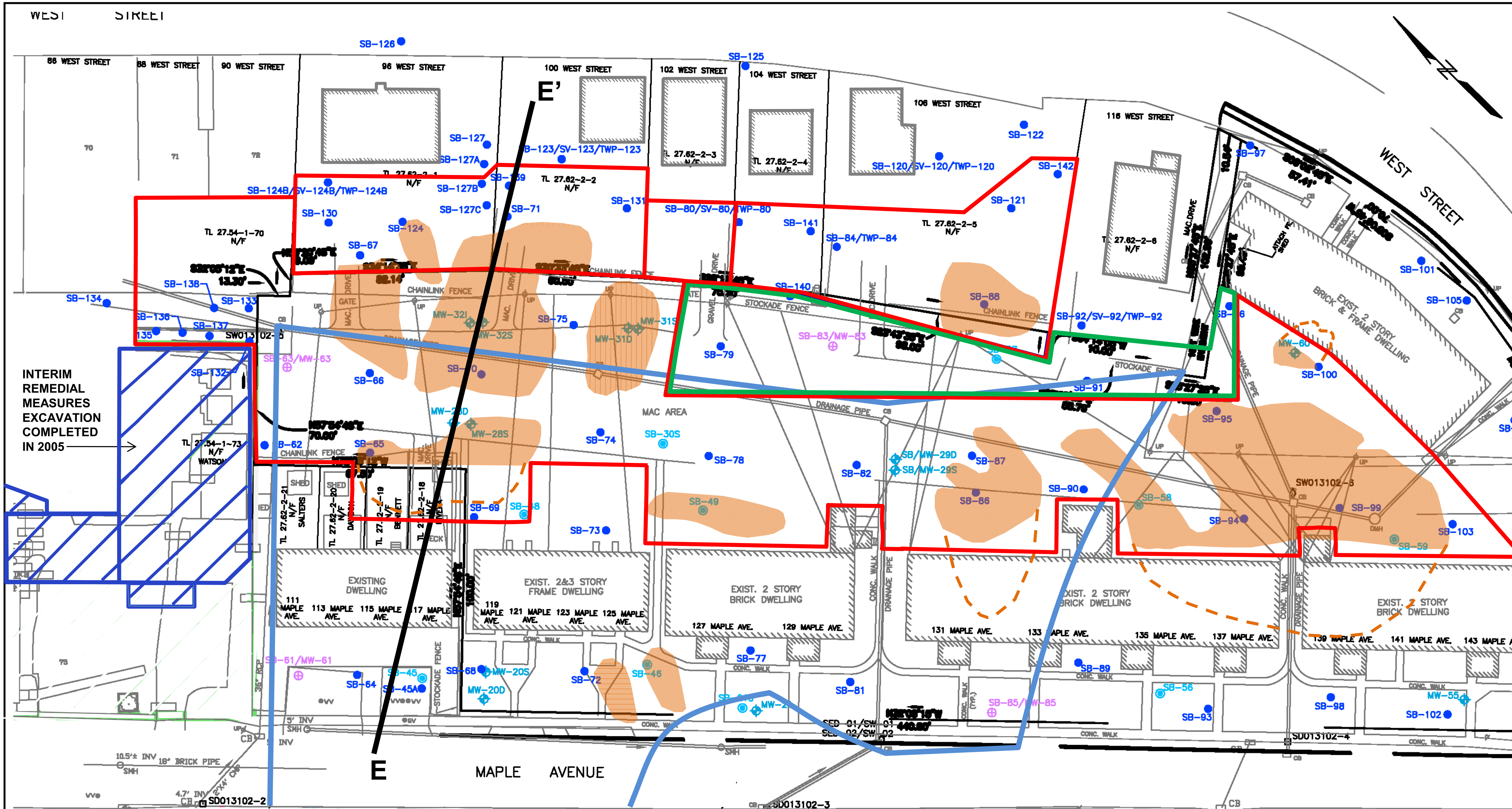
LEGEND:

- APPROXIMATE EXTENT OF SURFACE SOIL EXCEEDANCES OF NYSDEC PART 375 USCO.
- APPROXIMATE EXTENT OF SUBSURFACE SOIL EXCEEDANCES OF NYSDEC PART 375 USCO.
- EXTENT COULD NOT BE CONFIRMED DUE TO PROPERTY ACCESS RESTRICTIONS.
- APPROXIMATE EXTENT OF GROUNDWATER EXCEEDANCES OF NYSDEC AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES.
- * MW-24 HAD NO EXCEEDANCES EXCEPT ONE PAH, CHRYSENE, AT 0.5 mg/LJ (ESTIMATED VALUE).
- APPROXIMATE LIMIT OF IRM ACTIONS COMPLETED 2003-2005.

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

Figure 2 Extent Soil and Groundwater Contamination



LEGEND:

- ADDITIONAL DELINEATION REQUIRED
- EXCAVATION OF MATERIAL WITH TPAHs >25 ppm
- APPROXIMATE EXTENTS OF GROUNDWATER EXCEEDANCES OF NYSDEC AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES
- APPROXIMATE EXTENT OF SOURCE MATERIAL (GREATER THAN 0.2 FEET IN THICKNESS) FROM EVS 3D MODEL
- EXTENT OF POTENTIAL SOURCE MATERIAL BENEATH BUILDINGS

NOTES:

1. NOT FOR BIDDING OR CONSTRUCTION
2. BASE MAP FROM PLATE 2, 1/28/2009, CMX REMEDIAL INVESTIGATION REPORT, MAY 2009
3. EXISTING DWELLINGS ON WEST STREET APPROXIMATE FROM AIR PHOTOS
4. IRM EXCAVATION LIMITS APPROXIMATE, BASED ON FIGURE 3, RECORD EXCAVATION PLAN, GEI IRM CERTIFICATION REPORT, 93B MAPLE AVE, MARCH 31, 2006.

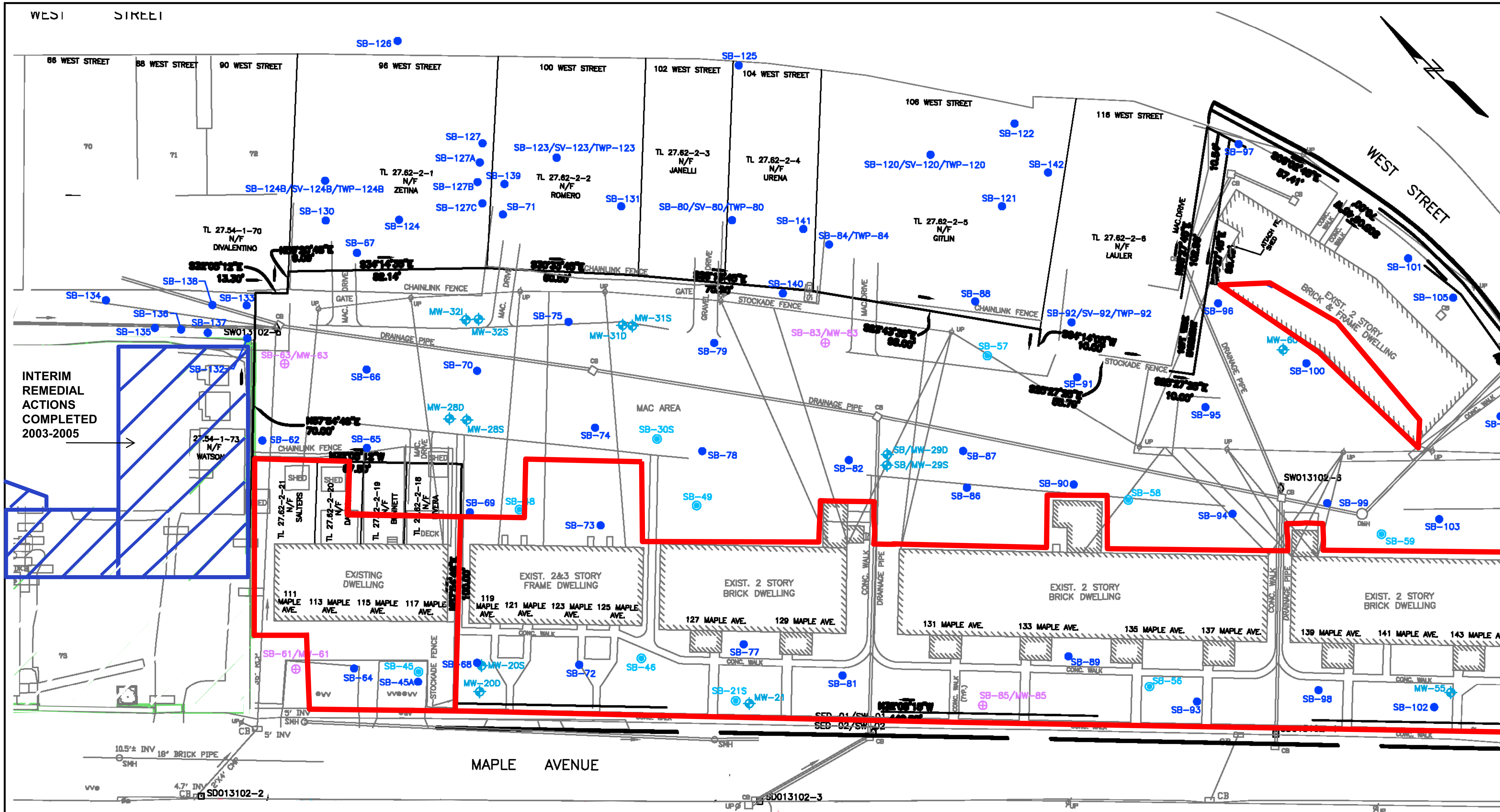
0 40 80
SCALE, FEET

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

Figure 3
Alternative 5 Phase 1

I:\GEI\Project\ORANGE AND ROCKLAND\HAVERSTRAW\091950\FS in PP\PHASE 6\C&M ALT 5A PHASE 1.ppt



LEGEND:

EXCAVATION OF MATERIAL WITH TPAHs >25 ppm (ADDITIONAL DELINEATION REQUIRED UNDER STRUCTURES)

NOTES:

1. NOT FOR BIDDING OR CONSTRUCTION
2. BASE MAP FROM PLATE 2, 1/28/2009, CMX REMEDIAL INVESTIGATION REPORT, MAY 2009

0 40 80

SCALE, FEET

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

Figure 4
Alternative 5 Phase 2

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APPENDIX A

Responsiveness Summary

RESPONSIVENESS SUMMARY

OR – Haverstraw Clove & Maple MGP Site
Operable Unit No. 02
Village of Haverstraw, Rockland County, New York
Site No. 3-44-049

The Proposed Remedial Action Plan (PRAP) for the Haverstraw Clove & Maple MGP site was prepared by the New York State Department of Environmental Conservation (the Department) in consultation with the New York State Department of Health (NYSDOH) and was issued to the document repositories on January 7, 2012. The PRAP outlined the remedial measure proposed for the contaminated soil and groundwater at the Haverstraw Clove & Maple MGP site.

The release of the PRAP was announced by sending a notice to the public contact list, informing the public of the opportunity to comment on the proposed remedy.

A public meeting was held on January 19, 2012 which included a presentation of the Remedial Investigation Feasibility Study (RI/FS) for the Haverstraw Clove & Maple MGP site as well as a discussion of the proposed remedy. The meeting provided an opportunity for citizens to discuss their concerns, ask questions and comment on the proposed remedy. These comments have become part of the Administrative Record for this site. The public comment period for the PRAP ended on February 6, 2012.

This responsiveness summary responds to all questions and comments raised during the public comment period. The following are the comments received, with the Department's responses:

COMMENT 1: Was the Head Start facility tested?

RESPONSE 1: Yes, the Head Start property was sampled as part of the remedial investigation. Sampling analytical results from soil, groundwater and soil gas samples obtained on the property did not detect contaminants at levels of concern.

COMMENT 2: Will any buildings be demolished under the proposed Alternative 5?

RESPONSE 2: The remedy will not require the demolition of any buildings. Remediation is being deferred until they are removed as part of a redevelopment of the property.

COMMENT 3: How close to the residential houses on West Street will the excavations be performed? Some of the houses were built in the late 1800s to early 1900s.

RESPONSE 3: The exact footprint of the excavations relative to the houses on West Street will be determined during design of the remedy. More data will be acquired to determine the depth and width of the excavations near the houses.

COMMENT 4: Are the residents expected to remain in the homes during remediation?

RESPONSE 4: We do not anticipate the need to displace the residents during the remedial activities. This issue will be further evaluated during design.

COMMENT 5: How will vibrations from construction activities be prevented from affecting the homes?

RESPONSE 5: The buildings will be inspected and existing conditions recorded prior to construction. Construction methods that will result in minimum vibrations will be evaluated and employed during construction. Based on existing conditions a program to monitor and record vibrations during construction will be designed and implemented.

COMMENT 6: How do you plan on dealing with the storm water drain pipe? This storm water pipe drains a large portion of the Village of Haverstraw.

RESPONSE 6: Based on the proposed excavation limits the pipe will most likely be removed and replaced, to allow the removal of contaminated soil. The proposed construction sequence and method of replacing the pipe will be identified during design. The design will identify and prepare contingency plans for large precipitation events based on prior information. Pipes of this type have been replaced as part of other remediation projects.

COMMENT 7: What is the plan in the area near the apartment complex in terms of remediation to protect the buildings and foundations?

RESPONSE 7: The remedial design will evaluate different methods for shoring and protecting the apartment buildings and their foundations. These methods will include an evaluation to determine excavation set back to assure the building's structural integrity.

COMMENT 8: If you will be using sheeting to shore the excavation, it may destroy the building foundations or pilings. There were concerns with the pilings under the apartment buildings, including concerns with impacts of dewatering on the piles.

RESPONSE 8: See Response 7.

COMMENT 9: How can you perform this work given the present use of the site?

RESPONSE 9: The construction work will need to be carefully planned and executed to minimize impacts from the activities on the community. One possibility includes sequencing the construction project in phases to allow smaller portions of work to proceed at a given time, to reduce the impacts.

COMMENT 10: Given the need for parking spaces, we suggest that this work be accomplished during the period of April 1 through November 15.

RESPONSE 10: The comment is noted and will be addressed in the remedial design. The availability of parking has been identified as an issue important to the residents and alternatives will be evaluated and implemented to address this concern.

COMMENT 11: How long will it take to complete the construction and how will you limit the impacts to the residents?

RESPONSE 11: The construction is estimated to take approximately 13 months to complete. The construction period may be extended to limit impacts to the community and address the concerns raised by the above comments. Also see Responses 9 and 16.

COMMENT 12: Can OU1 property be remediated and used for parking during the construction?

RESPONSE 12: The use of the OU1 property for interim parking space will be evaluated during design.

COMMENT 13: Will there be meetings with individual property owners before the construction period starts?

RESPONSE 13: Yes. The community outreach activities including availability sessions will continue and be enhanced through the design and construction phase of the project.

COMMENT 14: How fast is the MGP waste material moving in the soil and groundwater?

RESPONSE 14: The dissolved phase contamination travels along with the groundwater. The average horizontal groundwater flow velocity is measured in the feet per year.

COMMENT 15: If future redevelopment occurs, will there be a delay in removing the remaining material presently located under the buildings?

RESPONSE 15: There should not be a delay in remediating areas under the buildings when future redevelopment occurs. O & R will work with the property owner(s) to establish an appropriate schedule for the remediation.

COMMENT 16: Will there be vapor and odor issues during construction?

RESPONSE 16: While vapor/odor emissions are possible during the construction, they can be controlled with foam sprays, while potential dust disturbances are addressed by wetting down the dust-generating area with a water spray. A community air monitoring plan (CAMP) will be in place during all intrusive activities. The CAMP will require continuous monitoring for vapors, odors and dust and set action levels to protect the health of the community. Work at the site will be suspended if the established action levels are exceeded and work will not resume until all appropriate controls are implemented.

COMMENT 17: Instead of removal, has the DEC considered encapsulation/containment of the source material?

RESPONSE 17: Yes, an in-situ solidification alternative was evaluated in the feasibility study. This alternative would be equally disruptive and would require increased long term monitoring.

COMMENT 18: There were also comments made during the presentation on January 19, 2012 that the best way to complete the remediation on the apartment complex property would be to do the remediation in conjunction with redevelopment and removal of the existing structures.

RESPONSE 18: The remediation could be performed in conjunction with the redevelopment and removal of the existing structures. The Department will entertain this option if a redevelopment plan(s) should be presented prior to the construction of the remedy.

Maribeth McCormick, of Orange and Rockland, submitted a letter dated February 3, 2012, which included the following comments:

COMMENT 19: O&R maintains its position that the remedial alternative recommended in the original Feasibility Study (FS) submission (Alternative 4) is the most appropriate remedy for OU2. O&R is not disagreeing with the Department regarding the removal/treatment of the contamination, just the timing of the implementation. Alternative 4 balances the desire to remove impacted materials from the single family properties and address potentially mobile non-aqueous phase liquid (NAPL) in a portion of the parking area while minimizing disruption to residents and avoiding the risk of impacting existing structures. The Department has recognized that there are no current exposure pathways at the Site. Consequently, O&R believes that Alternative 4 provides as much risk reduction to humans and the environment while minimizing the short-term impacts associated with deep excavations in this heavily populated area when compared to Alternative 5. Alternative 4 will remove the same amount of impacted material as Alternative 5; it will, however, defer removal of the impacted materials close to the apartment buildings and townhouses until existing buildings are demolished for redevelopment, thus minimizing impacts to residents and property owners. If the Department maintains that additional remediation is required in Phase 1, O&R believes that NYSDEC should give further consideration to Alternative 6 (Excavation/ISS).

RESPONSE 19: The Department recognizes the complexities and difficulties with implementing a removal alternative in this setting. However, the Department has evaluated all available alternatives and determined that the proposed remedy will provide the most balanced protection of public health and the environment consistent with the present and future use of the site. The Department's regulations found in 6NYCRR 375-1.8(f) (9) call for the evaluation of the reasonably anticipated future use of the OU2 areas. The analysis presented in this document supports a remedy which achieves residential soil cleanup objectives consistent with the current zoning.

COMMENT 20: The PRAP states that a pre design investigation (PDI) will be performed to determine the depth and extent of excavation for those properties which were not fully delineated in the RI. The PRAP should also state that the actual distance from existing structures to the excavation limit cannot be determined at this time and will be established during design and with approval from the property owners. The PDI will include a comprehensive structural review to determine how close we can excavate next to the existing structures.

RESPONSE 20: The Department agrees with this comment. O&R and the Department will work with the property owners to keep them informed of project developments and issues concerning their properties. During the design and remediation of the properties steps will be identified and implemented to minimize impacts to the residents and any structures.

COMMENT 21: The reference to barrier "wall" should be removed. The Feasibility Study indicated the potential need for a barrier to prevent mobile NAPL from re-contaminating areas remediated during Phase 1 did not indicate the need for a wall type structure. The RI did not identify substantial mobile NAPL thus a temporary flexible barrier or left in place excavation support systems may be sufficient to prevent recontamination prior to Phase 2 implementation. The PRAP should state that an impervious barrier will be left in place after Phase 1 as determined in the design.

RESPONSE 21: In general the Department agrees, a "wall" may not be necessary, provided the objective of the barrier which is to prevent the remaining contaminated material from impacting the remediated areas, is achieved.

COMMENT 22: Please clarify the statement "The need to protect or relocate the line to allow the necessary excavation will be determined during the design phase of the project, provided the contaminated materials are addressed consistent with the remedial objectives and subject to field verification by the Department's on-site representative during construction."

RESPONSE 22: The primary objective is to remove the impacted material in the vicinity of the pipe. The Department expects options to meet this requirement will be evaluated during the design, but has no particular preference on how this is achieved.

COMMENT 23: Should there be separate SMPs for OU1 and OU2 given the different nature and ownership of the parcels and since one OU will be completed prior to remediation of the other OU?

RESPONSE 23: It is the Department's policy to have one Site Management Plan for the entire site, which can define specific approaches for each OU.

COMMENT 24: Engineering Controls – Please clarify "Any site redevelopment will require remedial action in this area (see bullet 8 below)." Should this be (see bullet 9 below)?

RESPONSE 24: The document will be revised to reference bullet 9 instead of bullet 8.

COMMENT 25: In Exhibit B, *Alternative 3* – Please remove the word "wall" from the title.

RESPONSE 25: The word "wall" has been replaced with Barrier in the title. Please see Response 21.

COMMENT 26: In Exhibit B, *Alternative 5 Phase 1* – Please remove reference to "wall" in title and 3rd bullet. See Item 4 above. In the 4th bullet, please add "and apartment complex parking lot" after "alleyway".

RESPONSE 26: A change was made to remove the word "wall" and to include apartment parking lot in the 4th bullet of Alternative 5.

COMMENT 27: In Exhibit B, *Alternative 5 Phase 2*– The 2nd bullet references the removal of "sheeting". As the method of excavation support has not been determined, any reference to sheeting should be removed.

RESPONSE 27: Agree. The reference to "sheeting" will be removed and replaced with the "installation of any temporary excavation support", as the method of excavation support will be determined in the design.

COMMENT 28: In Exhibit D, *Summary of the Proposed Remedy* – The third sentence in this paragraph states that the proposed remedy will treat contaminated groundwater using in situ technology. Since the majority of the source material will be removed during Phase 1, active treatment is not expected to be necessary nor was it included in the feasibility study cost estimate. The need for in situ treatment will be determined following remediation and will be based on post-Phase 1conditions.

RESPONSE 28: Given that subsurface contamination will be left under the buildings, it may be necessary to treat contaminated groundwater. Therefore, no change will be made in the ROD.

COMMENT 29: Basis for Selection, Section 2 – Compliance with NYS SCGs – The evaluation for Alternative 5 states that groundwater will be actively treated to enhance natural attenuation. As discussed above, the remedy does not call for active treatment at this time, only monitoring.

RESPONSE 29: See Response 28.

COMMENT 30: Basis for Selection, *Section 2 – Compliance with NYS SCGs* – Text states that Alternative 7 will remove all contaminated material from the site. This is inconsistent with other text in the PRAP that states that most or nearly all contaminated material would be removed (Exhibit B Alternative 7, 1st paragraph, page 9).

RESPONSE 30: Agreed. The text will be modified for consistency.

COMMENT 31: Basis for Selection, *Section 3 – Long Term Effectiveness and Permanence* – The discussion regarding the need for detailed engineering studies and treatability studies for Alternative 6 does not take into account the fact that detailed engineering studies will be required for all of these alternatives, including Alternative 5. While O&R acknowledges that there are uncertainties associated with in-situ solidification (ISS) implementation, we feel there are similar uncertainties with dewatering at this site and excavating in close proximity to the existing buildings. Therefore, this uncertainty should not be considered a reason to discount Alternative 6.

RESPONSE 31: The presence of the peat layer could impact the long term effectiveness of Alternative 6 which will need to be determined through detailed engineering and treatability studies. The Department believes the difficulties with implementing dewatering at the site and excavating in close proximity to the buildings also applies to Alternative 6. The challenges to implementing both Alternative 5 and 6 are substantial but the uncertainties associated with ISS are much greater than those associated with excavation options given the presence of the peat layer which raised concerns about long term effectiveness. However, concerning Alternative 6, the Department does not consider the alternative viable given the local zoning and the present and anticipated future use of the site.

COMMENT 32: Basis for Selection, *Section 4 – Reduction of toxicity, etc.* – This section states that contaminated groundwater will be treated in place under Alternative 5. Please see previous comments.

RESPONSE 32: See Response 28.

COMMENT 33: Basis for Selection, *Section 5 – Short Term Impacts and Effectiveness* – The PRAP states that Alternative 5 will result in fewer impacts to the community compared to Alternative 6. O&R disagrees with this conclusion and feels that the Department has minimized the impacts of implementing Alternative 5 in such close proximity to the apartment buildings. The reduced impacts due to the elimination of temporary fabric structures, thousands of truck trips, and the potential vibration nuisance and building risks associated with the installation of excavation support systems would indicate that Alternative 6 would actually be less disruptive than Alternative 5 while eliciting similar levels of noise during implementation. Please elaborate on the Department's rejection of ISS and Alternative 6 and acknowledge and discuss the true impacts of Alternative 5.

RESPONSE 33: The ISS alternative will require the excavation and removal of soil to accommodate the added solidification materials and expansion of the treated soil. The ISS foot print for construction, including the batch plant facility mixing and delivering the solidification materials, will impact the use of the property in a greater proportion than Alternative 5. The impacts of ISS are far greater than a properly sequenced excavation option during construction. However, ISS has been successfully used at a number of sites which have different site specific conditions which allow the application of an ISS technology. See Response 31.

COMMENT 34: Basis for Selection, *Section 7 – Cost Effectiveness* – Please clarify the statement, "Also, Alternative 5 will provide the most certainty for remedy implementation compared to Alternative 6." As stated above, due to the complex issues associated with dewatering at this site and designing excavation support systems that will not impact the existing structures and be acceptable to property owners, O&R feels that Alternative 6 may provide more certainty.

RESPONSE 34: See Responses 19, 31 and 33.

The following comments were received from Steven Pekofsky, owner of the Apartment Complex, in a letter dated February 6, 2012:

COMMENT 35: MT Associates II LLC (MT) is concerned with the health and safety of the building occupants.

RESPONSE 35: The Department shares this concern and will work with O&R and the NYSDOH to assure appropriate controls are in place to mitigate any potential adverse impacts to the health and/or safety of the residents during construction of the proposed remedy. Also see Response 16.

COMMENT 36: In considering Alternative 5 equal weight must be given not only to the objectives of NYSDEC but to the impact on the property while seeking those objectives.

RESPONSE 36: The Department believes these issues were taken into consideration during evaluation of the alternatives.

COMMENT 37: The practicalities and impacts of implementing the remedy should be factored into the selection of the remedy. The concern is with the feasibility of implementing the proposed remedy while meeting the remedial objectives of the proposed alternative.

RESPONSE 37: The Department recognizes the site specific conditions and challenges at this site and has fully considered these in proposing the remedy.

COMMENT 38: The design will be forced to comply with the mandates of the proposed remedial action plan.

RESPONSE 38: The Department, in selecting this remedy, has identified the need for additional evaluation of the specific means of implementing elements of the remedy to be further refined in the remedial design.

COMMENT 39: The remediation will need to consider the reduction in parking behind the apartment complex during construction and parking issues such as no street parking during the winter months. Off street parking is currently available to the apartment tenants for a fee and alternative parking would need to be made available during remediation.

RESPONSE 39: Agreed. O&R will be required to evaluate alternate parking arrangements during the design of the remedy and make the necessary accommodations to address the issue. See Responses 10 and 12.

COMMENT 40: The apartment building occupancy level would be reduced due to the lack of parking. This would result in lower rents, financial instability of the building, a diminished value of the property, and marketability.

RESPONSE 40: The Department will require O&R to provide alternate parking arrangements. See Response 39.

COMMENT 41: The alternative parking for tenants with young families that have children and bring their shopping goods into the building should be considered. In addition, older and handicapped people will need to have access to the apartment building entrances in the rear of the building.

RESPONSE 41: See Responses 39 & 40.

COMMENT 42: The police, fire and paramedics personnel and vehicles need to have access to the rear of the buildings at the apartment complex. Access to the rear of the apartment buildings is also needed for utility repairs by Orange & Rockland to access electrical power lines, transformers, fuse switches, and gas service. In the past there was a concern for abandoned vehicles and drug dealers in this area.

RESPONSE 42: The access to the rear of the building for police, fire and paramedic's personnel and vehicles will be evaluated during the remedial design, and O&R will be required to maintain the necessary access during remedy implementation, in accordance with their respective requirements.

COMMENT 43: The preliminary engineering studies performed in the feasibility study did not adequately evaluate the structural integrity of the building. More investigation is needed to determine what is supporting the footings. Additional studies need to be performed to determine effect of dewatering on the piles during excavation and reintroducing water on the adjacent piles. .

RESPONSE 43: Agreed. The remedial design will require O&R to perform all necessary engineering studies required to evaluate the structural integrity of the buildings, including the footings. The studies will also include the effect of dewatering on the piles during excavation and the reintroduction of water on the adjacent piles. Furthermore, the implementation of the remedy will include photo and structural inspections of the buildings before, during and after the construction to insure that the buildings are not impacted by the remedial activities.

COMMENT 44: The design needs to evaluate and consider the structural integrity of the building foundation when replacing or backfilling the soil adjacent to the building. There is sure to be movement and subsequent structural damage to the building foundation.

RESPONSE 44: See Response 43.

COMMENT 45: The property owner believes Alternative 5 will be too disruptive to the tenants of the apartment building due to the lack of a play area for children, lack of nearby parking, and potential competition with others trying to park on Maple Street.

RESPONSE 45: The Department will require O&R to design and implement the remedy to mitigate construction related impacts on the community to the greatest extent feasible. O&R is obligated to undertake the remediation to the extent feasible, given the current and reasonable future development plans for the property. If the property owner's development plans allow the full remedy or a reasonable portion to be implemented in the future, O&R should be informed of this decision. The Department will remain flexible with designing and implementing the selected OU2 and OU1 remedies with any future development plans provided the objectives of the Record of Decision are met in a reasonable timeframe. See Responses 10, 39 and 40.

COMMENT 46: The proposed remediation will be disruptive to the operation of MT, day to day management of the apartment complex property. The remediation will require additional personnel during the remedial construction and financial resources to coordinate and maintain a relationship with the tenants under these circumstances. MT does not have the resources to handle such a Project and is not willing to devote the time necessary to try and maintain the relationship needed with the Tenant's under these hardship circumstances.

RESPONSE 46: See Response 45.

COMMENT 47: The construction will affect the occupancy, rental income, cost of building operations, and place significant financial and time burden on MT.

RESPONSE 47: The comment is noted. See Response 45

COMMENT 48: Insurance for the apartment building will be difficult to obtain.

RESPONSE 48: The remedial contractor will obtain insurance and will be responsible for his actions during construction activities.

COMMENT 49: Refinancing the property when the mortgage becomes due will not be possible.

RESPONSE 49: The comment is noted. See Response 45.

COMMENT 50: MT does not agree with NYSDEC that Alternative 5 is the best alternative and should not go forward with such alternative.

RESPONSE 50: The comment is noted. See Responses 19 and 31.

COMMENT 51: The PRAP proposes no alternative whereby the entire property will be cleaned as in Alternative 7 except that the present owner retains title to the property.

RESPONSE 51: The selected alternative will eventually remove contaminated soil from the properties under different timelines extending into the future. Also see Response 45.

COMMENT 52: The PRAP proposes no alternative whereby the impacts are monitored for movement that would present a danger to health, safety and life and would otherwise leave the property intact until such time that it is redeveloped.

RESPONSE 52: Alternative 3 addresses this comment by initially removing non-aqueous phase liquid and postponing removing contaminated soil from the apartment complex to a later date. The selected Alternative also allows for certain areas of contamination to remain subject to future business decisions by the property owner.

COMMENT 53: Repeatedly the PRAP states there is no movement of NAPL or surface danger especially considering the time frame of 125 years. Further the Department of Health testified at the Public Meeting and repeatedly stated in the past that there was no danger to the public. While all parties involved want a clean environment and MT more than any party involved desires a clean property, the rush to do much surface damage is far greater than a few years wait for the property to be redeveloped.

RESPONSE 53: The PRAP did not state there is no movement of NAPL at the site. In Exhibit A, the Groundwater Section discussed the detection of dense non- aqueous phase liquid (DNAPL) at several monitoring well locations at the OU2 area. The proposed plan is predicated on present conditions and circumstances. The selected remedy is intended to mitigate the potential for future human exposures to site related contaminants and the ongoing impacts to the environment. The contaminated soils and groundwater have been documented to be above 6 NYCRR 375 Soil Cleanup Objectives and 6NYCRR 703 Ambient Water Quality Standards. The presence of such contamination in the soil and groundwater is not in compliance with New York State Standards, Criteria, and Guidance (SCGs) for which O&R is being required to address. See also Response 45.

COMMENT 54: MT's position is that as long as there is no surface contamination or threat of it, that all remediation work wait until permission is received by the Village of Haverstraw to redevelop the apartment complex. We object to any work being done on the site other than well monitoring until such time.

RESPONSE 54: See Response 53.

COMMENT 55: In the interim there is much additional feasibility work that needs to be done. The result of this additional feasibility work will indicate, and has been confirmed with MT's structural engineers, that work on the southern portion of the property is not feasible as proposed. The two alternative proposals suggested above have not been addressed and their remedies exhausted.

RESPONSE 55: The Feasibility Study reviewed and evaluated a number of alternatives in accordance with the Department's applicable regulations and guidance. Further investigations and evaluations into the manner in which the selected remedy (e.g., structural evaluations) will be implemented will be undertaken during the design of the remedy.

COMMENT 57: If it is the position of NYSDEC to proceed regardless then we need to discuss Alternative 7 either in light of the above mentioned format or a price based on market value, not as suggested by GEI whose formula was at the very least, naive.

RESPONSE 57: The comment is noted. The Department believes that the proposed alternative is the most balanced and cost effective alternative in addressing the site contamination. See Responses 19, 31 and 53.

APPENDIX B

Administrative Record

Administrative Record

OR – Haverstraw Clove & Maple MGP Site
Operable Unit No. 02
Village of Haverstraw, Rockland County, New York
Site No. 3-44-049

1. Proposed Remedial Action Plan for the OR-Clove and Maple-Haverstraw Former MGP Site, Operable Unit No.2, dated December 2011, prepared by the Department.

2. Orders on Consent: Index No. D3-0002-94-12, between the Department and O&R, executed on January 8, 1996; Index No. D3-0001-98-03 executed on September 29, 1998; and Index No. D3-0001-99-01 executed on March 11, 1999.

3. "Preliminary Site Assessment Report for Two Former Manufactured Gas Plant Sites, Haverstraw, New York", August 1997, Remediation Technologies, Inc.

4. "Remedial Investigation Report, Former Clove and Maple Manufactured Gas Plant Site", January 2009, CMX.

5. "Feasibility Study Report, Clove and Maple Avenues Former Manufactured Gas Plant", September 2010, GEI Consultants, Inc.

6. "Surface Soil Investigation and Risk Assessment Report for Former Manufactured Gas Plant Site at Clove and Maple in Haverstraw, New York", August 1997

7. Letter dated February 1, 2012 from Maribeth McCormick of Orange & Rockland Utilities, Inc.

8. Letter dated February 6, 20012 from Steven Pekofsky of MT Associates II LLC

Appendix B

Pre-design Investigation Work Plan

AECOM Environment

Prepared for:
Orange and Rockland Utilities, Inc.
3 Old Chester Road
Goshen, NY 10924

Prepared by:
AECOM
Chelmsford, MA
Project 60288163
July 18, 2013

Pre-Design Investigation Work Plan

Clove and Maple Avenues, Haverstraw Former MGP Site
Village of Haverstraw, Rockland County, New York
NYSDEC Site # 3-44-049

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Pre-Design Investigation Work Plan

Clove and Maple Avenues, Haverstraw Former MGP Site
Village of Haverstraw, Rockland County, New York
NYSDEC Site # 3-44-049

Caroline Bardwell

Prepared By: Caroline Bardwell, CPG, CHMM

Reviewed By: Thomas Clark, P.E.

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CERTIFICATION

I, Thomas P. Clark, certify that I am currently a NYS registered professional engineer and that this Pre-Design Investigation Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

7/18/13

Thomas P. Clark Date
Registered Professional Engineer
New York License No. 085258

1.0 Introduction

This Pre-Design Investigation (PDI) Work Plan (PDIWP) presents the sampling locations, rationale, field methods, and laboratory methods that will be employed to support the remedial design at the Clove and Maple Avenues, Haverstraw former manufactured gas plant (MGP) site OU-2 (Site, NYSDEC Site # 3-44-049), located in Haverstraw, New York. Figure 1-1 shows the Site location. The remedial design will be developed in accordance with the Administrative Order on Consent (AOC) Index No. D3-0001-98-03 between New York State Department of Environmental Conservation (NYSDEC) and Orange & Rockland Utilities, Inc. (O&R) and the Record of Decision (ROD) issued for the O&R Clove and Maple MGP Operable Unit #2 issued March 2012. The selected remedy consists of excavation and off-site disposal of MGP-impacted soil above the soil cleanup objectives (SCOs).

O&R has performed a series of environmental studies focusing on the Site and nearby properties. An Initial Hazard Assessment was completed in 1996, followed by a Preliminary Site Assessment in 1997 and a Surface Soil and Risk Assessment in 1998. A Remedial Investigation (RI) was started in 1998; this was composed of multiple phases of field work, analysis, and review. The RI produced several reports, and resulted in a DEC-approved Remedial Investigation Report (RIR) in May 2009 (CMX, 2009). Following the acceptance of the RIR, a Feasibility Study (FS) was prepared. During this process the Site was broken into three Operable Units (OUs), consisting of:

- **OU-1:** The MGP parcel owned by O&R and the drainage swale located between the O&R property and 104 Maple Avenue.
- **OU-2:** The off-site properties, including: the Apartment Complex property comprising four apartment buildings on Maple Avenue and one apartment building on West Street; single-family row house residential properties on Maple Avenue, consisting of four adjacent properties at 111, 113, 115, and 117 Maple Avenue; and single-family residential properties on West Street, consisting of six properties at 96, 100, 102,104, 108, and 116 West Street. All of these properties are zoned residential. OU-2 also includes a portion of the Alleyway between the rear property line of 103 Maple Avenue and residential properties on West Street; and a portion of Maple Avenue between 103 and 131 Maple Avenue.
- **OU-3:** Sediments in the nearby Hudson River embayment.

The triangular parcel at the intersection of Maple Avenue and West Street, owned by the Village of Haverstraw, and the parcel at 146 Maple Avenue, which houses the Head Start facility, were included in the RIR study area but were deemed to be substantially unimpacted by the MGP, and so were not included in the areas requiring remedial action. After a public meeting and responsiveness survey, NYSDEC issued a Record of Decision (ROD) (NYSDEC, 2012) for the Site in March 2012. The layout of the site is shown in Figure 1-2.

This PDIWP primarily addresses OU-2. However, where advantageous for overall efficiency and modeling, some activities will be conducted on OU-1 as well. OU-3 will be addressed separately.

As outlined in Section 3.3 of DER 10, specific requirements for investigation work plans are provided in the following sections:

- Section 2 contains the Site history and description.
- Section 3 describes the PDIWP objectives, scope and rationale.
- Section 4 provides a quality assurance project plan (QAPP).
- Section 5 describes health and safety protocols.
- Section 6 presents the PDI schedule.

2.0 Site History and Description

This section provides a summary of the Site history and description as provided in the RIR and FS (CMX, 2009; GEI, 2011). A site plan providing additional detail is available in the RIR document (CMX, 2009).

2.1 Site Description

OU-2 consists of several residential parcels, as shown in Figure 1-2. The overall size of OU-2 is approximately 115,200 square feet or 2.64 acres. Significant Site features include the former pond area and residential structures, which are described in three groups.

2.1.1 Former Pond Area

Historical mapping and photography indicates that a stream previously flowed past the nearby 93B MGP site and through the OU-2 area, roughly parallel with Maple Avenue. The stream was apparently dammed near the intersection of West Street and Maple Avenue, forming a pond area that covered a large portion of OU-2. The stream was subsequently directed underground and relocated to the existing 54-inch culvert. The 54-inch storm sewer is located beneath the alleyway and Apartment complex parking lot. It runs from Tor Avenue behind the 93B Maple Avenue site down to the Apartment Complex property on OU-2.

2.1.2 Apartment Complex Parcel

The Apartment Complex parcel is an approximately 2.5-acre, irregularly-shaped property identified as Tax Map Section 27, Block 62, Lot 17 and zoned residential. The apartment buildings contain 56 apartments which house a total of over 200 residents. The property includes four 2- and 3-story apartment buildings, located on the north side of Maple Avenue across from the MGP and Head Start properties, and a 2-story apartment building on West Street. All buildings in the apartment complex are built on concrete slabs with no basements or crawl spaces. Reportedly, these slabs may bear on a deeper pile foundation. However, record plans have not been located to date to confirm or refute this detail. Small grassy areas and laundry facility outbuildings are located behind the apartment buildings. Paved parking and driveway areas comprise the remainder of the property between the apartment buildings and the neighboring lots. Emergency vehicle access to the rear of the buildings is from West Street and Tor Avenue via the Alleyway. Numerous electrical power poles and overhead building service lines are located behind the buildings. The 54-inch storm drain and three lateral storm drain pipes are located on the property.

2.1.3 Single-Family Residences on Maple Avenue

A row house building and associated properties are located west of the Apartment Complex on Maple Avenue. The properties are identified as Tax Map Section 27, Block 62, Lots 18, 19, 20, and 21 and are zoned residential, with addresses listed as 111, 113, 115, and 117 Maple Avenue. The row house is built on slabs without basements or crawl spaces. Vehicle parking is located in front of the building on Maple Avenue and fenced yard areas with decks, sheds, and additional parking are located behind the building.

2.1.4 Single-Family Residences on West Street

Six properties are located on West Street immediately north of the Apartment Complex parcel. These are identified as Section 27, Block 62, Lots 1, 2, 3, 4, 5, and 6. Each of these properties includes a single-family residence at 96 through 116 West Street. Most of the houses abut closely to West Street with grassy and paved backyard areas. Vehicle access for some of these properties is from the rear of the lots, via the Alleyway and the Apartment Complex driveway to West Street.

2.1.5 Maple Avenue

Maple Avenue is a narrow, two-way, paved street with a concrete sidewalk on the north side. Utility poles and overhead electrical and telephone lines are located on the south side of the street. The utilities located beneath the street and sidewalk include water, sanitary sewer, storm drains, and natural gas.

2.2 Site History

According to historical records it appears that the MGP operated for approximately 48 years, between 1887 and 1935. Circa 1935, natural gas was introduced into the area, and the MGP operations ceased. The plant structures were demolished in the 1960s. The general configuration of the MGP did not substantially change over the operating period. The historical records indicate that MGP structures included an above-grade gas holder, an above-grade high pressure holder, an above-grade iron oil tank (30,000 gallons), a coke shed, a tar well, and gas generator and purifier rooms. A specific type of carbureted water gas process, known as the Boecklin process, was used at the Site which utilized both coal and crude oil as feedstock in the production of the gas. Additional details regarding the MGP history are provided in the RIR (CMX, 2009).

The MGP parcel is currently owned by O&R and has a retired natural gas regulator station on the property, along with inactive natural gas lines. The on-grade holder foundation, approximately 65 feet in diameter, exists in the northwest corner of the Site. The property is currently unoccupied and consists mostly of a landscaped, mowed grassy area, three large trees, and a hedgerow of trees along Maple Avenue. It is fenced with a locked gate located on Clove Avenue. The topography slopes down from Clove Avenue to the midpoint of the property, with a 75-foot wide, flat terrace over the northern half of the Site, closest to Maple Avenue. The hedgerow of trees is on a sloped bank down to Maple Avenue. Along the western boundary, a drainage swale is present that intermittently directs stormwater runoff to a storm culvert beneath Maple Avenue; however, ownership of the drainage swale is uncertain at this time.

Prior to the MGP operations at the Clove and Maple Site, a gas plant was in operation at 93B Maple Avenue, located to the northwest on the opposite side of Maple Avenue. The 93B MGP site and nearby properties were previously investigated and were remediated during a series of Interim Remedial Measures (IRMs) between 2003 and 2005. The remediation included excavations on properties immediately adjacent to the area now identified as OU-2 of the Clove and Maple MGP Site. An IRM excavation was also conducted in 2005 at 104 Maple Avenue, adjacent to OU-1 of the Clove and Maple site. Additional detailed information regarding these IRMs is provided in the IRM Certification Report (GEI, 2006).

3.0 Pre-Design Investigation Objectives, Scope, and Rationale

3.1 Objectives

During preparation of the FS and the Remedial Design Work Plan (RDWP), additional information was identified as necessary to complete the remedial design. The purpose of this PDI is to gather the additional information required to design the selected remedy for the Site as specified in the ROD. The objectives of this PDI are:

- Collect geotechnical data, including blow counts, on the soils within and along the perimeter of the excavation areas for analysis and design of the excavation support system(s).
- Perform geotechnical testing of soils collected during subsurface borings for modeling soil conditions as part of excavation design.
- Collect analytical data to demonstrate the feasibility of reusing shallow, unsaturated site soils meeting the reuse criteria in 6 NYCRR Part 375 and DER-10 for site-specific residential soil cleanup objectives identified in Section 3.4.2. The site-specific SCO for total PAHs is 25 mg/kg. For all other constituents, SCOs for residential use established in 6 NYCRR Part 375 will be applied.
- Observe soil and groundwater behavior during test pitting on the Site to reveal potential constructability impediments.
- Record subsurface structures that may present obstructions during excavation, including utilities which will require demolition and/or relocation.
- Further delineate the vertical and horizontal limits of MGP-related impacts that require subsurface soil excavation via field classification of soils and analytical testing.
- Further investigate the Site hydrology to include seasonal and storm event fluctuations, reported artesian pressures in underlying soil units, and soil permeability.
- Collect data on stormwater flows in the on-site storm sewer main and laterals to prepare for temporary bypass pumping during construction and review of adequacy of current configuration.
- Assess Site construction water discharge options based upon required sampling and available/allowable discharge capacities.
- Observe the construction and condition of the foundations of the Site buildings via interior inspections for the purpose of excavation design.
- Observe below grade construction of building foundations slated to be demolished, depending on access and schedule.
- Obtain a topographic, property boundary and utility survey to serve as the design base map. This survey will meet the DER- 33 requirements so that it can be used for any deed restrictions that may be required following the completion of remedial construction.

Pre-characterization of soil to meet the requirements of off-site waste management facilities is not included as part of the proposed work. Waste characterization required to implement the remedial action will be performed at a later date.

3.2 Pre-Design Investigation Scope and Rationales

The PDI will consist of the following activities:

- Geotechnical drilling will include hollow stem auger (HSA) methods and cased drive and wash rotary methods. Standard penetration testing (SPT) will be used to collect soil samples for geotechnical analysis and delineation of excavation limits.
- Direct-push drilling will be used to collect soil samples for chemical analysis to facilitate delineation of excavation limits and evaluations of potential soil reuse.
- Test pits will be excavated to collect information on subsurface features including the storm drain and other subsurface utilities and soil and groundwater characteristics.
- Physical soil testing will be performed to evaluate geotechnical properties.
- Storm sewer flow monitoring will be performed.
- Aquifer testing will be performed to allow evaluation of excavation dewatering alternatives.
- Topographic, property boundary, and utility surveys will be completed to provide a Site map for remedial design and to meet requirements for utility protection.

All proposed boring and test pit locations are predicated on property owner approval and access agreements to allow entry to the particular location. Actual locations will be determined during field implementation.

These activities are described in more detail below.

3.2.1 Utility Clearance

Underground and overhead utilities, including electric lines, gas lines, storm and sanitary sewers, and communication lines will be identified prior to initiation of drilling and other subsurface work. Underground utility location will be accomplished as follows:

- All boring locations will be flagged or marked out with survey stakes and/or marking paint.
- Dig Safely of New York (800) 272-4480 will be contacted to initiate the locating activities. New York State law requires that Dig Safely of New York be notified at least two working days, and not more than 10 working days, before subsurface work is conducted.
- Companies with subsurface utilities present will locate and mark out all subsurface utility lines.
- Precautions regarding safe distance from the overhead electrical lines will be reviewed and equipment offset distances flagged and marked out in accordance with the O&R required clearances.
- Prior to advancement of boreholes, the locations will be pre-cleared to a depth of five feet using a combination of manual methods and hydro-excavation.

3.2.2 Geotechnical Borings

Twenty geotechnical borings will be advanced to gather geotechnical information for the purpose of designing the excavation shoring. The proposed location of geotechnical borings is presented in Figure 3-1. Eight borings will be advanced using a truck-mounted drilling rig equipped with 4.25-inch I.D. HSAs. Eight borings, which will be converted into monitoring wells, will be drilled in a two-step process. First 10.25-inch I.D. HSAs will be used to drill into the visually non-impacted clay. Then 6-inch I.D. cast iron or steel casing will be set and grouted in place. Following adequate set-up time the borings will then be advanced using drive and wash methods within 4-inch flush joint drill casing Additionally, for the HSA borings, in the event that auger refusal is encountered prior to reaching a boring's target total depth, flush-joint drill casing of appropriate size will be advanced through (telescoped) the augers using drive and wash methods to reach the desired depth. Continuous split spoon soil samples will be collected from each soil boring.

The borings are proposed in locations that provide comprehensive coverage across the main portion of the former pond location. Additional borings are then located along the northeast boundary of the Site (130 West Street) and on the OU-1 parcel. These borings are proposed to confirm soil properties across the Site and capture the variation of soil properties to the extent practicable. The borings will be used to create inferred cross-sections through the excavation areas to model the soil conditions for the required excavation shoring.

Borings will also be used to collect information on the geohydrologic characteristics of the semi-confined deep sand unit, which may be under artesian pressure. For this purpose, eight of the borings will be converted into new monitoring wells upon completion. In order to avoid drawing contamination beneath the confining layer and into the sand aquifer, the top 15 to 25 feet will be cased off at these locations per the methods discussed above. Due to previously documented artesian conditions at some monitoring well locations, during previous groundwater gauging events, all new wells will be constructed as raised steel casing wells (i.e., "stick-up wells"), unless it is unacceptable to the owner or municipality. In order to produce a more accurate model of conditions across the entire Site (i.e., OU-1 and OU-2), two of the wells are proposed in OU-1.

The borings will be continuously logged, recording blow counts, the presence of fill material or subsurface obstructions, the nature of each geologic unit encountered, observations regarding moisture content, the PID readings, and visual and olfactory observations regarding the presence of hydrocarbon-like residuals. Borings, in general, will extend to a depth of approximately 50 feet or top of the glacial till unit, whichever is encountered first. A representative number of borings (approximately five) will be advanced to a depth of 65 feet below ground surface to collect data to determine the required bottom or "tip" elevation of the excavation shoring components. If bedrock is encountered, though unlikely from previous investigation results, a five- to ten-foot rock core may be collected based on the AECOM field supervisor's evaluation.

All boreholes will be abandoned using non-shrinking cement-bentonite grout to fill the void space left by the auger flights.

Appendix A contains standard operating procedures (SOPs) that will be employed during the work. Table 3-1 summarizes the SOPs to be applied.

The twenty geotechnical borings will be advanced using HSA and/or wash rotary drilling techniques as follows:

1. All borings will be advanced to the glacial till unit. From data collected during previous investigations at the site it is anticipated that the glacial till unit will be encountered between 20 and 35 feet below ground surface.
2. A total of 16 borings will be installed across the central portion of the OU-2 site.
3. Two borings will be installed along the frontage of 130 West Street.
4. Of the twenty total geotechnical borings; at least five on OU-2 will be extended into the glacial till deposit to an estimated depth of 65 feet below ground surface to confirm that shoring components can be driven into the till to the required depth without obstruction.
5. Six of the OU-2 borings will be used to install 2-inch diameter monitoring wells into the semi-confined deep sand unit for use in a pump test evaluation.
6. Two geotechnical borings will be advanced in the OU-1 site. These borings will also be converted to 2-inch diameter monitoring wells to assess the characteristics of the semi-sand unit as groundwater flows from OU-1 to OU-2. Target boring depth will be 50 feet below ground surface on the Maple Avenue side of OU-1 and 65 feet below ground surface on the Clove Avenue side of OU-1.

Sufficient geotechnical samples will be analyzed to provide a realistic representation of soil conditions. Thin-walled tube samples (Shelby tubes) would be collected for a representative portion of the fine grained soils (clay) encountered. The following geotechnical analyses will be performed to facilitate excavation support design:

- Grain size analysis (also provides data for WWTP-filter design) –20 samples
- Atterberg Limits (fine grained soils) –6 samples
- Unconfined compressive strength tests (fine grained soils) –6 samples
- Permeability testing of deep sand unit –10 samples
- Moisture Content –30 samples
- Unit Weight (fine-grained soils) –2 samples
- Specific Gravity –2 samples (sand)

Table 3-2 summarizes method references for geotechnical analysis. Sample quantities will be finalized based upon subsurface conditions encountered.

3.2.3 Delineation Borings

In order to fill data gaps, further identification of the vertical and horizontal limits of MGP impacts on the Site is required. These borings will be advanced using direct-push drilling methods. The general locations of the delineation borings are presented as clusters of borings within sub-areas of the Site. These numbered sub-areas are shown in Figure 3-1 and include:

1. <u>Apartment Complex parking lot L:</u> (near SB-83, also extends onto 106 and 116 West Street): Four borings are proposed in order to more fully delineate impacts in this area. Target depth of these borings will be approximately 10 to 14 feet below ground surface (bgs). Impacts in this area have been recorded in the soil layer that formed the bottom of the former pond.

2. Single family residence property at 86 West Street: Two borings are proposed in this area to further delineate the horizontal extent of impacts. Impacts in the area, as reported in the RI, have been confined to the fill and alluvium units in this area. Target depths will be approximately 8 to 10 feet bgs. If the two borings closest to the storm sewer are impacted, then another pair of contingency borings will be installed.
3. Single family residence property at 102 West Street (extends onto 100 West St. property as well): Three borings are proposed to a target depth of approximately 14 to 18 feet bgs. The organic clay/peat soil layer(s) is present nearby in SB-75 at a depth of 20 feet bgs; therefore, borings may need to extend as far as 22 feet bgs to confirm the bottom of impacts.
4. Portions of the Apartment Complex near 130 West Street: Two borings are proposed to further delineate impacts in this area. Historical data from surrounding borings indicates there are impacts in this area while TarGOST borings showed little or no impacts. This area also abuts or overlaps with the area near SB-83 discussed above. Target depth for these borings will be approximately 10 to 14 feet bgs.
5. Single family residence at 111 and 113 Maple Avenue: One delineation boring is proposed on each parcel to determine if impacts are consistent with those along Maple Ave. and the northwest OU-2 property line. One boring is proposed in the front yard of 111 Maple Ave. and one boring is proposed in the backyard of 113 Maple Ave. (shed is no longer present and there is an access opening in the fence. The objective of these borings will primarily be to delineate shallow impacts to a depth of approximately 12 to 14 feet bgs. Additionally, as discussed in Section 3.2.1, a geotechnical boring is proposed at the western edge of the 111 Maple Ave. parcel near the curb line of Maple Ave. that will also serve to confirm that deeper impacts are not present on this parcel that were noted at the top of the glacial till on OU-1 directly across the street and at a depth of 25 feet bgs in nearby SB-45.
6. The eastern end of the 143 Maple Ave. parcel: Two borings are proposed in this area to confirm that impacts are not present at the property line between the apartment complex and the Village of Haverstraw property. Proposed depth is approximately 10 to 16 feet bgs based upon the nearest borings where impacts were present. The number and placement of the delineation borings is presented for overview of the required work; however, the actual locations may be adjusted based on field conditions.

The borings will be continuously logged, recording the presence of fill material or subsurface obstructions, the nature of each geologic unit encountered, observations regarding moisture content, the PID readings, and visual and olfactory observations regarding the presence of hydrocarbon-like residuals.

Samples will be collected from borings and submitted for chemical laboratory analysis. If no impacts are observed in a boring, then a confirmatory sample will be collected from approximately 8 to 10 feet bgs, to correspond to a depth where the majority of impacts have been observed on OU-2. If impacts are observed, a sample will be collected from the unimpacted interval beneath the MGP waste if it is at a depth less than 15 feet to confirm the vertical extent of impacts. Samples will be submitted for laboratory analysis of VOCs and SVOCs via standard turnaround time. Laboratory analytical methods are summarized in Table 3-3.

Table 3-1 summarizes standard operating procedures to be used. Appendix A contains SOPs that will be employed during the work.

3.2.4 Test Pits

Test pits will provide information on the constructability of remedial measures (i.e. behavior of soils and infiltrating water), which cannot be explored with subsurface borings alone. Figure 3-3 presents the proposed test pit locations. Test pits will also aid in constructability assessment since the behavior of the soils during excavation, even test pitting, provides information used to determine the extent of dewatering of excavation cells that will be necessary prior to excavation. Additionally these test pits provide information to confirm soil conditions in the upper fill soils that will be used to determine the level of effort required to excavate/segregate soils to the least costly waste streams or, if feasible, reuse. Test pit designation used during the RI will continued for the PDI. Locations may be modified in the field based on site conditions at the time of the work. Table 3-1 contains SOPs that will be employed during the work. SOPs are provided in Appendix A.

The locations and purpose of the test pits are:

- Up to five test pits will be excavated on the apartment complex property and in the Alleyway to determine construction details of and backfill materials present around the 54” storm sewer to aid in design of required shoring systems around the storm sewer.
- Five test pits will be excavated to confirm feasibility of excavation/segregation of potential reuse soils and assess behavior of soil/water.
- No test pits are currently proposed within the footprints of the buildings along Maple Avenue since they are expected to remain intact upon completion of the Remedial Design. If owner access is granted, then two test pits will be installed adjacent to 115 and 123 Maple Avenue to assess foundation construction.

Test pits are intended to extend to a maximum depth of 15 feet below grade; however, the actual depth will be dependent on field conditions and the objectives at each location. Test pits will be excavated using a mini track-mounted or rubber-tire backhoe. If the prospective test pit location is covered by concrete or asphalt pavement, the area will be saw-cut prior to excavation. Care will be taken to limit the size of the test pit/trench to only what is necessary to achieve the investigation objectives and keeping in mind site disturbance and restoration needs. During test pit investigation activities, personnel will stand upwind of the excavation area to the extent possible. Air monitoring and odor mitigation (if necessary) will be conducted in accordance with the Community Air Monitoring Plan (CAMP) and Health and Safety Plan (HASP).

The proposed approach to test pit dewatering will be to excavate as deeply as possible below the water table while limiting the total amount of water generated. No more than 30 drums of water total will be generated from test pits. This represents an average of three drums per test pit. If a test pit cannot be effectively dewatered given this limitation, it will be backfilled without reaching its proposed depth. Drums of water will be managed as Investigation Derived Waste.

A field representative will record test pit observations on a test pit log and will make note of soil classification, presence of debris/cobbles, softness/hardness of material/layers, presence of perched water, rate of infiltration of water, etc. Test pit materials will be photographed and logged for future reference. Material removed from the test pit will be placed on polyethylene sheeting. Upon completion, the materials from the test pit will be placed back in the excavation in the reverse order in which it was removed. The location and size of the test pit will be measured and described in the field logbook.

Care will be taken during test pitting to segregate and sort soils for replacement when the excavation is complete. Visually clean soil, impacted soil, and heavily impacted soil will be segregated in separate piles. If the field work supervisor determines heavily impacted soil is not suitable for replacement in the excavation, the material will be removed for off-site disposal as investigation-derived waste. To the extent possible, soil replaced in the test pit will be placed at a level where similar levels of impacts are found. Visually clean soils will be used to cover the impacted soils when placed back in the excavation. At a minimum, the top two feet of backfilled soil will be visually clean.

The test pit will be backfilled as soon as possible after completion and prior to the cessation of activities at the end of the day. The existing surface will be restored in kind at the completion of test pitting activities, with the exception of paving. Grassy surfaces will be finished with topsoil and seed, while test pits in concrete/asphalt areas will be finished with gravel, compacted, and patched to limit settlement and surface disruption. Following restoration of the excavation, the test pit will be staked/marked to facilitate subsequent location by surveying crews.

No samples will be collected and analyzed during the test pitting activities.

3.2.5 Reuse Soils Evaluation

Based on the FS, there is a potential that some soil to be excavated may be suitable for reuse. Some of this material includes fill that contains coal fragments, ash, and cinders. The overall approach is to collect screening samples to evaluate the feasibility of reuse of these soils during construction. A total of ten soil samples collected from borings installed to collect geotechnical and delineation data will be analyzed for the full suite of analytes as outlined in DER-10 and summarized in Table 3-3 and compared against Soil Cleanup Objectives (SCOs). Samples will be collected during pre-clearing activities from within the top five feet of soil from a mixture of geotechnical and delineation borings (see Figures 3-1 and 3-3). Field personnel will gather a representative data set including potential PAHs from ash, cinders, and coal fragments. If screening samples indicate reuse is feasible, then reuse characterization may occur concurrently with waste disposal pre-characterization efforts or during remedial construction.

3.2.6 Groundwater Data Collection

Groundwater elevations at existing and new wells will be collected to refine the dewatering design for construction. Although the design is currently scheduled for end of 2013 completion, four quarterly gauging events are proposed to gather data on seasonal groundwater fluctuation, since remedial construction activities will occur over a full year. The design will incorporate the data that is in hand (including historical data) at the time of submittal. Additionally, two rounds of aquifer response to substantial rain events (i.e. a spring baseline and then a day after a one inch plus rain event) will be collected.

Semi-confined deep sand unit hydraulic testing, slug testing, will be conducted at the newly installed wells to more fully determine the hydraulic conditions in the deep sand unit below the Site, which reportedly demonstrates artesian characteristics in some locations. The testing will be conducted to facilitate the design of dewatering efforts for the remedial construction. The existing monitoring wells are screened through two or more soil units, which is not appropriate for hydrogeologic testing of groundwater in the semi-confined sand unit. Therefore new monitoring wells screened discretely within the deep sand unit will be utilized for the hydraulic investigation.

Hydraulic conductivity testing, using slug and/or bail testing, of at least six (6) of the newly installed monitoring wells will be performed to provide the data necessary to evaluate the horizontal hydraulic conductivity of the semi-confined sand unit, and allow an evaluation on both the potential variability and mean of this important hydrogeologic parameter.

Limited modeling of hydraulic conditions will be performed to depict groundwater elevation data and refine shoring/cut-off wall requirements. Based on the results of that evaluation, O&R will determine whether performance of an aquifer pump test is required in order to complete the design. If the test is required, a scope of work will be developed and submitted to NYSDEC.

SOPs for planned activities, summarized in Table 3-1, are provided in Appendix A.

3.2.7 Investigation-derived Waste Management

All investigation-derived waste (IDW) generated during the PDI will be collected in properly labeled, new (not refurbished) 55-gallon drums or bulk containers (e.g. roll-off container lined with polyethylene sheeting for solids, fractionation tanks for liquids). IDW includes soil cuttings, decontamination pad and plastic sheeting, personal protective equipment (PPE), decontamination water, well development water, and water generated during test pitting.

Drums and containers of material will be labeled as "**PENDING ANALYSIS – INVESTIGATION-DERIVED WASTE**" with a description of the source (e.g., soil cuttings, decon water, pump test water, etc.) and temporarily stored pending characterization and proper disposal. The containerized soils will be disposed of offsite at a facility permitted to accept such material.

Containers will be properly labeled, and characterized for disposal as hazardous or non-hazardous waste.

Soil will be analyzed for the following:

- Toxic Characteristic Leaching Procedure (TCLP) volatile organic compounds (VOCs)
- TCLP semi-volatile organic compounds (SVOCs)
- TCLP Metals
- Total Petroleum Hydrocarbons (TPH)
- Reactivity
- Flash Point
- Polychlorinated biphenyls (PCBs)
- pH

Table 3-3 summarizes analytical methods.

3.2.8 Community Air Monitoring Plan

Community air monitoring requires real-time monitoring for VOCs, and particulates (i.e., dust), at the downwind perimeter of each designated PDI work area when land disturbing activities are in progress at the Site. The community air monitoring is intended to provide protection for the downwind community (i.e., residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigation work activities.

Real time monitoring will be performed at a total of two stations (upwind and downwind) for VOCs and particulates during all drilling and test pitting activities. One set of backup meters will be maintained on-site in case of malfunction.

VOC monitoring will be performed using a photo ionization detector (PID) located within the work zone. If the concentration of total VOCs exceeds 5 parts per million (ppm) above background, then work activities will be temporarily halted. If the total VOC level then decreases below 5 ppm over background, work activities will resume. If the total VOC levels persist at levels in excess of 5 ppm, work activities will be halted, the source of the vapors identified, and corrective actions taken to abate the emissions until the concentrations drop below the action levels.

Particulate monitoring will be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 microns in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. Each particulate monitor will be calibrated daily with a filtered air sample. Each air monitoring instrument will be downloaded at the completion of the PDI activities and saved along with project electronic data.

Table 3-4 describes the action levels for perimeter particulate air monitoring and the associated responses to each level.

3.2.9 Site Survey

In conjunction with the PDI, a field survey will be conducted to assist with the preparation of a base map suitable for the project design work. This work would be completed concurrently with the subsurface investigations. The survey work will include field data collection and compilation of information from available mapping (village and utility companies), if available, to establish the mapping of and around the project limits:

- Property Boundary Survey – This would consist of establishing and recording property boundaries for each of the parcels in the affected area to be used for preparation of access agreements and designing the remediation work and sequencing. As part of this work existing property surveys on record with the city and county will be obtained and reviewed. The boundary survey will include key site features and buildings. Any existing building plans and records will be reviewed and incorporated into the Site base mapping. Additionally, any existing easements will be identified for incorporation into the Site base mapping. This survey will meet the DER- 33 requirements so that it can be used for any deed restrictions that may be required following the completion of remedial construction.
- Level A Utility Survey – This level of utility survey requires physical confirmation of utility components using water jetting/vacuum excavation or limited test pitting excavation to expose the utilities. A Level A utility survey will be needed to complete the Remedial Design for location of shoring components, sequencing of excavations and requirements for utility deactivation and replacement. Some utilities may require removal and replacement or temporary relocation. Additionally any semi-permanent or permanent components of the previously completed IRMs that affect the remedial design, i.e. sheet piling left in place, will be incorporated into the Site base map.

- Topographic Survey – A topographic survey is proposed to be completed for the entire upland portion of the “Study Area” from the RIR. This includes all of OU-1 and OU-2. Topography will be used to compute more accurate disposal, reuse and import soil volumes as well as provide for a basis of the restoration grading plan. The topographic survey would be completed concurrently with the subsurface investigations.

In addition, all PDI boring, well and test pit locations will be surveyed for elevation and location. This information, as well as previous sample locations throughout the project area, will be incorporated on the site base map.

3.2.10 Storm Sewer Flow Monitoring

Flow data will be collected within the storm sewer onsite as well as all of the applicable lateral connections by installing flow monitoring sensors to record actual flow rates in real-time within the storm sewer and lateral feeders. Data will be transferred from the sensors via telemetry in order to facilitate real-time monitoring and allow adjustment of sensors, if necessary. This data will be used to evaluate the flow conditions in the storm sewer. A minimum of 8 weeks of monitoring will be performed.

4.0 Quality Assurance Project Plan

This section describes the quality assurance (QA) requirements for the PDI as specified in DER-10.

4.1 Project Organization

This PDI will be performed by AECOM on behalf of O&R. AECOM will arrange for the drilling and analytical services and provide on-site field representative to perform the soil characterization, soil sampling, sediment, and groundwater sampling. The consultant will also perform the data interpretation and reporting tasks. Key contacts for this project are as follows:

4.1.1 O&R Project Manager:

Maribeth McCormick
Orange and Rockland Utilities, Inc.
3 Old Chester Road
Goshen, New York 10924
Telephone: (845) 783-5534
Cell: (917) 557-1361

4.1.2 AECOM Project Manager:

Thomas Clark, P.E.
AECOM
250 Apollo Drive
Chelmsford, MA
Telephone: (978) 905-2161
Cell: (978) 303-9033

4.1.3 AECOM Field Team Manager:

Matt Thorpe, P.E.
AECOM, Inc.
40 British American Blvd.
Latham, NY
Telephone: (518)-951-2318
Cell: (518)-428-4383

4.1.4 AECOM Quality Assurance Officer:

Greg Malzone
AECOM, Inc.
707 Grant Street, 5th Floor
Pittsburgh, PA
Telephone: (412) 316-3524

4.1.5 Laboratory Representative:

The laboratory has yet to be selected.

4.2 Sampling and Testing Procedures

The following section details the sampling and testing procedures which will be followed during this PDI. The chosen laboratory for the project will be certified, and maintain certification, under the NYSDEC Environmental Laboratory Approval Program (ELAP) and the New York State Department of Health (NYSDOH) ELAP Contract Laboratory Program (CLP) for analyses of solid and hazardous waste.

All sampling equipment will be properly decontaminated before being reused or disposed of accordingly. Samples will be collected in pre-cleaned sample containers provided by the laboratory performing analysis with any necessary preservations added to the sample containers at the laboratory prior to sample collection. Coolers with ice will be used to store samples at 4 degrees Centigrade (°C) until delivered to and analyzed by the laboratory.

4.2.1 Environmental Testing

Samples collected for environmental analysis will be analyzed for Total VOCs via EPA Method 8260 and Total SVOCs via EPA Method 8270. These VOC/SVOC samples will require quality control samples, including field duplicate and matrix/matrix-spike duplicates at a frequency of 1 per 20 samples. COC procedures will be followed to document that contamination of samples has not occurred during container preparation, shipment, and sampling. Table 3-3 provides a summary of requirements.

Reuse characterization samples will be analyzed for the DER-10 parameters, including Total VOCs, Total SVOCs, PCBs/Pesticides, and Total Target Analyte List (TAL) Metals. The reuse samples are solely intended for screening and therefore will not warrant quality control samples, data validation, or electronic data submission.

IDW characterization will also not require quality control samples, data validation, or electronic data submission.

4.2.2 Geotechnical Analysis

Samples collected for geotechnical analysis will be analyzed for the parameters specified in Section 3 and summarized in Table 3-2. SOPs for sample collection and field testing methods are summarized in Table 3-1 and included in Appendix A.

4.3 Sample Tracking and Custody

This section presents sample custody procedures for both the field and laboratory. Implementation of proper custody procedures for samples generated in the field is the responsibility of field personnel. Both laboratory and field personnel involved in the COC and transfer of samples will be trained on the purpose of the COC and specific procedures prior to implementation.

Evidence of sample traceability and integrity is developed by implementation of, and adherence to, the COC procedures. These procedures document the sample traceability from the selection and preparation of the sample containers by the laboratory, to sample collection, to sample shipment, to laboratory receipt and analysis. A sample is considered to be in a person's custody if the sample is:

- In a person's possession.

- Maintained in view after possession is accepted and documented.
- Locked and tagged with custody seals so that no one can tamper with it after having been in physical custody.
- In a secured area which is restricted to authorized personnel.

4.3.1 Field Sample Custody

A COC record accompanies the sample containers from selection and preparation at the laboratory, during shipment to the field for sample containment and preservation, and during return to the laboratory. Triplicate copies of the COC must be completed for each sample set collected.

The COC lists the field personnel responsible for taking samples, the project name and number, the name of the analytical laboratory to which the samples are sent, and the method of sample shipment. The COC also lists a unique description of every sample bottle in the set. If samples are split and sent to different laboratories, a copy of the COC record will be sent with each sample.

The “Remarks” space on the COC is used to indicate if the sample is an MS/MSD, or any other sample information for the laboratory. Since they are not specific to any one sample point, trip and equipment blanks are indicated on separate rows. Once all bottles are properly accounted for on the form, a sampler will write his or her signature and the date and time on the first “Relinquished By” space. The sampler will also write the method of shipment, the shipping cooler identification number, and the shipper air bill number on the top of the COC. Errors will be crossed out with a single line in ink and initialed and dated by the author.

One copy of the COC is retained by sampling personnel and the other two copies are put into a sealable plastic bag and taped inside the lid of the shipping cooler. The cooler is wrapped tightly with clear packing tape. It is then relinquished by field personnel to personnel responsible for shipment, typically an overnight carrier. The packing tape must be broken to open the container. Breakage of the tape before receipt at the laboratory may indicate tampering. If tampering is apparent, the laboratory will contact the Project Manager, and the sample(s) will not be analyzed.

4.3.2 Laboratory Sample Custody

The Project Manager or Field Team Leader will notify the laboratory of upcoming field sampling activities and the subsequent shipment of samples to the laboratory. This notification will include information concerning the number and type of samples to be shipped as well as the anticipated date of arrival.

The following laboratory sample custody procedures will be used:

- The laboratory will designate a sample custodian who will be responsible for maintaining custody of the samples and for maintaining all associated records documenting that custody.
- Upon receipt of the samples, the custodian will check cooler temperature, and check the original COC documents and compare them with the labeled contents of each sample container for correctness and traceability. The sample custodian will sign the COC record and record the date and time received.

- Care will be exercised to annotate any labeling or description errors. In the event of discrepant documentation, the laboratory will immediately contact the Project Manager or Field Team Leader as part of the corrective action process. A qualitative assessment of each sample container will be performed to note any anomalies, such as broken or leaking bottles. This assessment will be recorded as part of the incoming COC procedure.
- The samples will be stored in a secured area and, if required, stored at a temperature of 4°± 2°C.
- A laboratory tracking record will accompany the sample or sample fraction through final analysis and final storage for control.

A copy of the tracking record will accompany the laboratory report and will become a permanent part of the project records.

4.4 Reporting

Data will be provided in electronic format, including the following specific requirements:

- All data generated will be submitted in an electronic data deliverable (EDD) that complies with the DEC's Electronic Data Warehouse standards (EDWS) or as otherwise directed by DER.
- Preliminary or final reports will be submitted to the DER in an electronic format that complies with DEC’s Electronic Document Standards (EDS) or as otherwise directed.
- Data Usability Summary Reports (DUSR) will be prepared in accordance with NYSDEC procedures, which are included in Appendix B.

4.5 Data Quality Usability Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements to ensure that data of known and appropriate quality are obtained during sampling and analysis activities. Data developed during the PDI will be used to fulfill the overall objectives of the program. Evaluation of DQOs is preformed following procedures in U.S. Environmental Protection Agency (USEPA) National Functional Guidelines for Data Review. Generally, the validation uses 1) method specification limits, 2) laboratory statistically calculated limits based on historical data, and finally 3) default limits from the USEPA National Functional Guidelines.

The quality assurance and quality control (QA/QC) objectives for all measurement data include precision, accuracy, representativeness, completeness, and comparability. These objectives are defined in the following subsections. They are formulated to meet the requirements of the USEPA SW-846, the analytical methods and their Contract Required Quantitation Limits (CRQLs), and Contract Required Detection Limits (CRDLs).

4.5.1 Precision

Precision is an expression of the reproducibility of measurements of the same parameter under a given set of conditions. Specifically, it is a quantitative measurement of the variability of a group of measurements compared to their average value. Precision is usually stated in terms of standard deviation, but other estimates such as the coefficient of variation (relative standard deviation), range (maximum value minus minimum value), relative range, and relative percent difference (RPD) are common.

For this project, field sampling precision will be determined by analyzing coded duplicate samples (labeled so that the laboratory does not recognize them as duplicates) for the same parameters, and then, during data validation, calculating the RPD for field duplicate sample results.

The data quality objectives for analytical precision, calculated as the RPD between duplicate analyses, will be statistically calculated laboratory control limits based on historical data. Should there be insufficient data to calculate limits; the validation default RPD limits will be used: 20% for aqueous samples and 35% for soils.

4.5.2 Accuracy

Accuracy is a measure of the degree of agreement between a measured value and the true or expected value of the quantity of concern, or the difference between a measured value and the true or accepted reference value. The accuracy of an analytical procedure is best determined by the analysis of a sample containing a known quantity of material, and is expressed as the percent of the known quantity which is recovered or measured (percent recovery).

Sampling accuracy may be determined through the assessment of the analytical results of field blanks and trip blanks for each sample set. Analytical accuracy is typically assessed by examining the percent recoveries of surrogate compounds that are added to each sample (organic analyses only), and the percent recoveries of matrix spike compounds added to selected samples and laboratory blanks. Additionally, initial and continuing calibrations must be established and be within method control limits. Instrument and method analytical accuracy can then be determined for any sample set.

The data quality objectives for analytical precision, calculated as the percent recovery, will be statistically calculated laboratory control limits based on historical data. Should there be insufficient data to calculate limits, the validation default percent recovery limits will be used: 70-130% for organic analyses, and 75-125% (matrix spike recovery) and 80-120% (laboratory control spike (LCS) recovery) for inorganic analyses.

4.5.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is most concerned with the proper design of the sampling program. Samples must be representative of the environmental media being sampled. Selection of sample locations and sampling procedures will incorporate consideration of obtaining the most representative sample possible.

Field and laboratory procedures will be performed in such a manner as to ensure, to the degree that is technically possible, that the data derived represents the in-place quality of the material sampled. Every effort will be made to ensure that chemical compounds will not be introduced into the sample via sample containers, handling, and analysis. Decontamination of sampling devices and digging equipment will be performed between samples. Analysis of field blanks, trip blanks, and method blanks will also be performed to monitor for potential sample contamination from field and laboratory procedures.

The assessment of representativeness also must consider the degree of heterogeneity in the material from which the samples are collected. Sampling heterogeneity will be evaluated during data validation through the analysis of coded field duplicate samples. The analytical laboratory will also follow acceptable procedures to assure the samples are adequately homogenized prior to taking aliquots for analysis, so the reported results are representative of the sample received.

COC procedures will be followed to document that contamination of samples has not occurred during container preparation, shipment, and sampling.

4.5.4 Completeness

Completeness is defined as the percentage of measurements made which are judged to be valid. The QC objective for completeness is generation of valid data for at least 90% of the analyses requested

4.5.5 Comparability

Comparability expresses the degree of confidence with which one data set can be compared to another. The comparability of all data collected for this project will be ensured by:

- Using identified standard methods for both sampling and analysis phases of this project.
- Requiring traceability of all analytical standards and/or source materials to the USEPA or National Institute of Standards and Technology (NIST).
- Requiring that all calibrations be verified with an independently traceable standard from a source other than that used for calibration.
- Using standard reporting units and reporting formats including the reporting of QC data.
- Performing a complete data validation on all of the analytical results, including the use of data qualifiers in all cases where appropriate.
- Requiring that all validation qualifiers be considered any time an analytical result is used for any purpose.

These steps will ensure all future users of either the data or the conclusions drawn from them will be able to judge the comparability of these data and conclusions.

4.5.6 Sensitivity

Soil, water, and waste samples will be analyzed according to the USEPA SW-846 "Test Methods for Evaluating Solid Waste," November 1986, 3rd edition and subsequent updates. The methods to be used for the laboratory analysis of soil samples are presented in Table 4-1. These methods were selected because they attain the quantitation limits and DQOs required by the project, which are also compiled on the table.

4.6 Equipment Decontamination Procedures

The following decontamination procedure will be followed for all non-disposable sampling equipment before being reused.

- Equipment will be washed thoroughly with a non-phosphate detergent.
- The equipment will then be rinsed with analyte-free water.

After decontamination, equipment will be carefully stored to avoid contamination between sampling events.

All down-hole drilling tooling will be washed thoroughly using brushes, steam cleaners, and/or pressure washers and an appropriate biodegradable cleaning solution for the level of contamination present. All down-hole tooling that has been used in a boring advancement will be decontaminated before reuse in a subsequent boring and before demobilization. The excavator bucket will be decontaminated in the same manner between locations.

5.0 Health and Safety Protocols

5.1 Site Hazards

There are physical hazards which may be present at the Site associated with existing conditions and with investigation activities. Potential physical hazards include the following:

- Traffic – Requires care when entering and leaving the Site.
- Overhead and underground utilities - Overhead power lines near road and in the apartment complex parking lot. Potential underground utilities during drilling and test pitting.
- Mechanical equipment including drill rigs and excavators.
- Slips, trips, and falls – General site hazards. Debris inside and outside of buildings, rough surfaces.
- Exposure to hazardous wildlife and plants.

A number of environmental investigations have been performed at the Site between 1996 and 2009. These investigations were documented in the RI Report (CMX, 2009). The RI indicates that coal tar which contains volatile and semi-volatile organic compounds including benzene, toluene, ethylbenzene, and xylenes (BTEX), and polynuclear aromatic hydrocarbons (PAHs) is present in subsurface soils and groundwater at the Site.

All AECOM staff will be bound by the provisions of the HASP and O&R's standard contractor H&S requirements. All field staff are required to participate in a preliminary project safety meeting to familiarize them with the anticipated hazards and respective onsite controls. The discussion will cover the entire HASP subject matter, putting emphasis on critical elements of the plan; such as the emergency response procedures, personal protective equipment, site control strategies, and monitoring requirements. In addition, daily tailgate safety meetings will be held to discuss: the anticipated scope of work, required controls, identify new hazards and controls, incident reporting, review the results of inspections, any lessons learned or concerns from the previous day. Attendance rosters from all safety meetings will be signed by all present and incorporated into the project records. AECOM subcontractors will formally agree to sign off on AECOM's HASP. If the subcontractor has additional or more stringent requirements, they will be submitted to AECOM and O&R for review.

Further detail on Health and Safety protocols for the Site are presented in the Site Specific HASP, which will be provided separately.

6.0 Schedule

The primary PDI activities will begin upon NYSDEC approval of this PDIWP. It is O&R's intention to begin topographic, property line, and utility survey work prior to NYSEC approval of the workplan. The field portion of the work is expected to require six to eight weeks of onsite activities. This will begin as soon as practicably possible after approval of the PDIWP, but will be dependent upon subcontractor scheduling and access agreements with the property owners. O&R will inform NYSDEC at least 10 calendar days prior to conducting the work. The PDI summary report will be submitted to NYSDEC approximately 60 days after the completion of the field work.

7.0 References

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RETEC, 1997. Surface Soil Investigation and Risk Assessment Report for Former MGP Site at Clove and Maple in Haverstraw, Prepared by Remediation Technologies, Inc. August 13, 1997.

RETEC, 2005. Clove and Maple Avenue Former MGP Sites, Haverstraw, NY. Soil Gas, Indoor and Ambient Air Sampling of February 2005. Preliminary Evaluation of Results. Prepared by The RETEC Group, Inc. March 23, 2005.

Tables

Table 3-1 List of Standard Operating Procedures and ASTM Methods

Field Activity	Standard Operating Procedure/ASTM Method
Direct Push Borings	• Description of Soil and Manufactured Gas Plant Residuals • SOP 7116 - Subsurface Soil Sampling by Direct Push Methods • ASTM D 2488 –Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) • ASTM D 4220 - Standard Practices for Preserving and Transporting Soil Samples • ASTM D 5434 – Field Logging of Subsurface Explorations of Soil and Rock
Geotechnical Borings	• Description of Soil and Manufactured Gas Plant Residuals • SOP 7115 - Subsurface Soil Sampling by Split Spoon • ASTM D 1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils • ASTM D 1587 - Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes • ASTM D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation • ASTM D 2488 –Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) • ASTM D 4220 - Standard Practices for Preserving and Transporting Soil Samples • ASTM D 5434 – Field Logging of Subsurface Explorations of Soil and Rock • ASTM D 6032 – Determining Rock Quality Resignation for Rock Core • ASTM D 6151 - Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
Test Pits	• Description of Soil and Manufactured Gas Plant Residuals • SOP 7230 – Test Pit Procedures • ASTM D 2488 –Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) • ASTM D 5434 – Field Logging of Subsurface Explorations of Soil and Rock
Sample Collection	• SOP 7510 – Packaging and Shipment of Environmental Samples • SOP 7600 – Decontamination of Field Equipment
Aquifer Testing	• SOP 7220 – Monitoring Well Construction and Installation • SOP 7221 – Monitoring Well Development • SOP I-C-4 – Aquifer Testing

Table 3-2 Geotechnical Analysis

Sample Type	Matrix	Method
Particle Size	Soil	ASTM D422
Moisture Content	Soil	ASTM D2216
Specific Gravity	Soil	ASTM D854
Atterberg Limits Testing	Soil (Fine grained soils only)	ASTM D2850
Tri-axial compression	Soil (Fine grained soils only)	ASTM D2850/ASTM D4767

Table 3-3 Waste Characterization Sampling

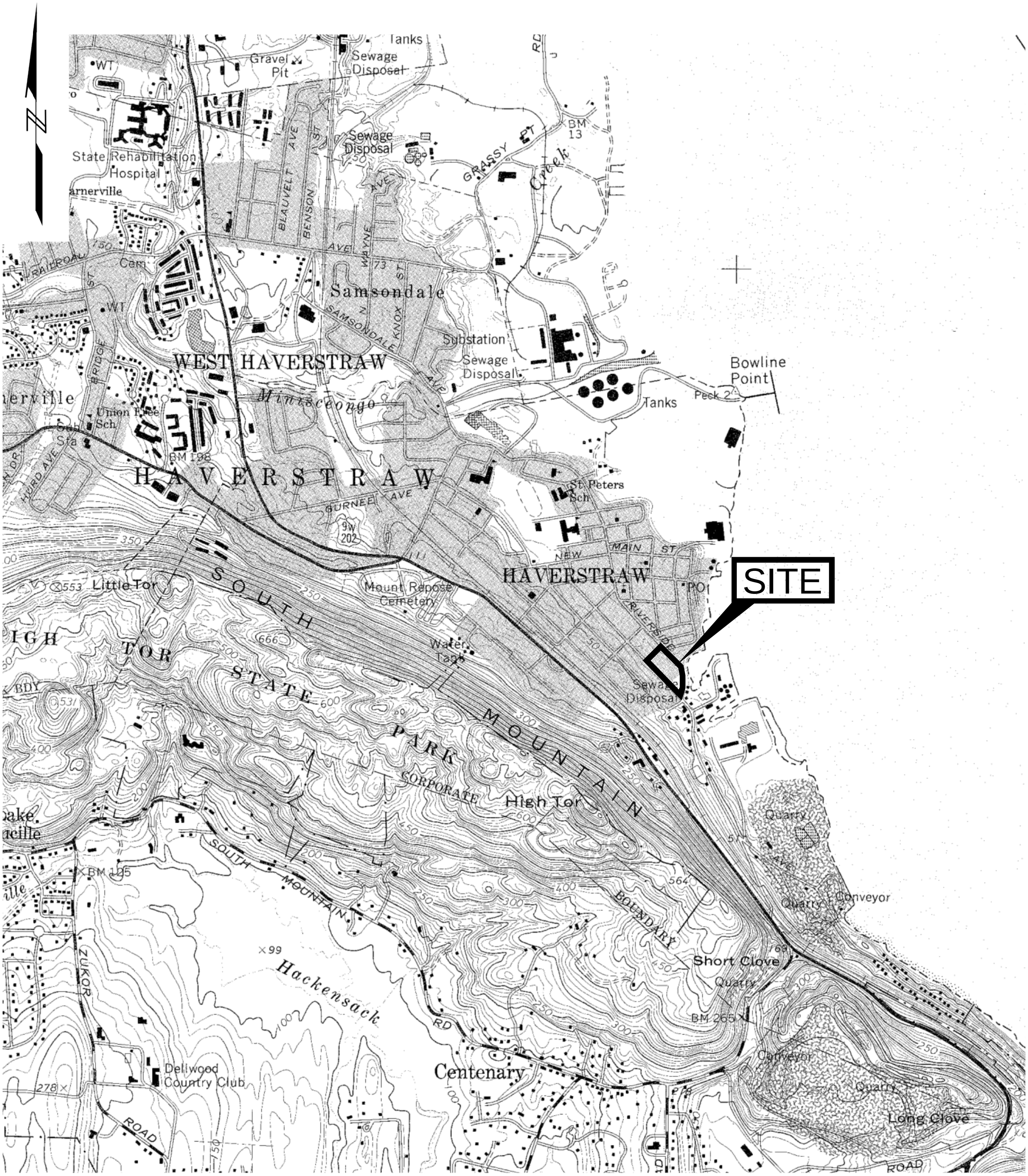
Sample Type	Matrix	Holding Time	Method
VOCs TCL	Soil	7 days	U.S. EPA Method 8260B
SVOCs TCL	Soil	14 days	U.S. EPA Method 8270C
Metals (14 Metals)[1]	Soil	180 days	U.S. EPA Method 6010B/7471A
Total Cyanide	Soil	14 days	U.S. EPA Method 9012A
TPH	Soil	14 days	U.S. EPA Method 8100 or 8015DRO
Total PCBs	Soil	14 days for extraction/40 days for analysis	U.S. EPA Method 8082
% Sulfur	Soil	28 days	ASTM D129-64
BTU Content	Soil	28 days	ASTM D240-87
TCLP VOCs	Soil	14 days (TCLP extraction); 7 days (after extraction)	U.S. EPA Method 1311/8260B
TCLP SVOCs	Soil	14 days (extraction); 40 days (after extraction)	U.S. EPA Method 1311/8270C
TCLP Metals	Soil	180 days (TCLP extraction)	U.S. EPA Method 1311/6010B
TCLP Herbicides	Soil	14 days (TCLP extraction); 7 days (preparative extraction); 40 days (after extraction)	U.S. EPA Method 1311/8151A
TCLP Pesticides	Soil	14 days (TCLP extraction); 7 days (preparative extraction); 40 days (after extraction)	U.S. EPA Method 1311/8081A
Ignitability (Flashpoint)	Soil	N/A	U.S. EPA Method 1010
Corrosivity (as pH)	Soil	7 days	U.S. EPA Method 9045C
Reactive Sulfide	Soil	7 days	U.S. EPA Method 8030B/9034
Reactive Cyanide	Soil	14 days	U.S. EPA Method 9012A
Paint Filter		180 days	SW-846 Method 9095A
% Solids		28 days	SM20 2540G

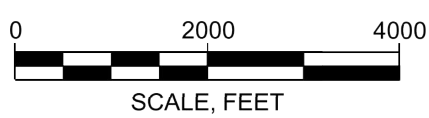
[1] Metals include Arsenic, Barium, Cadmium, Chromium (total), Lead, Mercury, Selenium, silver, Antimony, Beryllium, Nickel, Thallium, Vanadium and Zinc

Table 3-4 Action Levels For Perimeter Particulate Air Monitoring

Action Level	Response
Ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average.	Work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring
Total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm.	Work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.
If the organic vapor level is above 25 ppm at the perimeter of the work area.	Activities must be shutdown. The source of the vapors identified, corrective measures taken to abate emissions, and monitoring continued. Work activities can resume once the organic vapor level is less than 25 ppm at the perimeter provided all other provisions of the CAMP are followed.
Downwind particulate concentrations 100 **µ**g/m3 greater than upwind particulate monitor sustained over 15 minute average	Dust suppression techniques are employed
Downwind particulate concentrations 150 **µ**g/m3 greater than upwind particulate monitor sustained over 15 minute average	Work halted and dust suppression techniques evaluated. Work continues once dust suppression techniques are proven successful

Figures





SOURCE: USGS TOPOGRAPHIC MAP, HAVERSTRAW, N.Y. 1979

AECOM

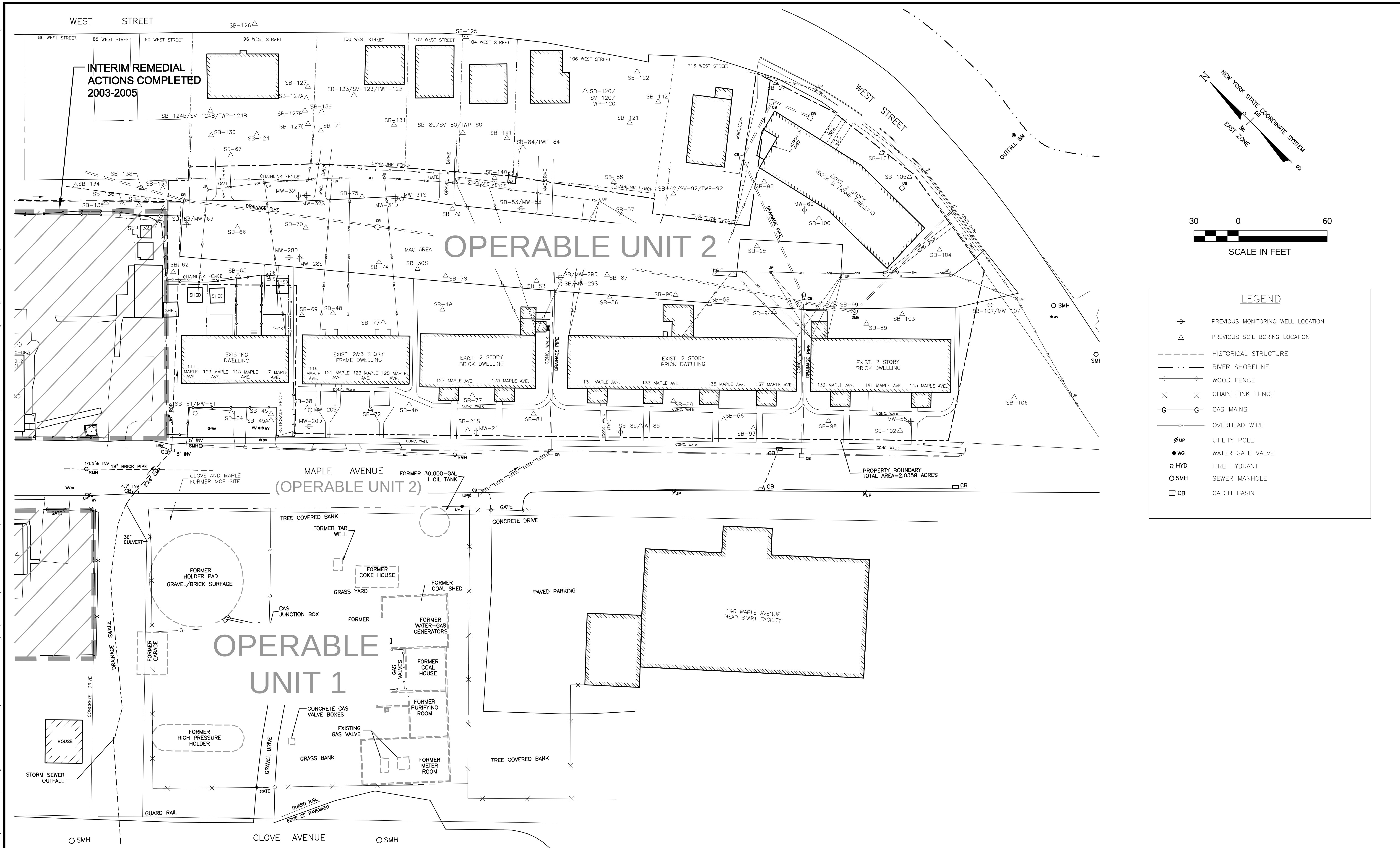
CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK
ORANGE AND ROCKLAND UTILITIES, INC.

SITE LOCATION PLAN

DATE: 07/16/13 | DRWN: RCW

FIGURE 1-1

File: J:\Rem_Eng\Project Files\Orange & Rockland\Haverstraw Design\7.0 Project Documents\7.2 CADD\RDWP & PDIWP\Site Location Map.dwg Layout: Layout1 User: warrenr Plotted: Jul 16, 2013 – 3:49pm Xref's:



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AECOM

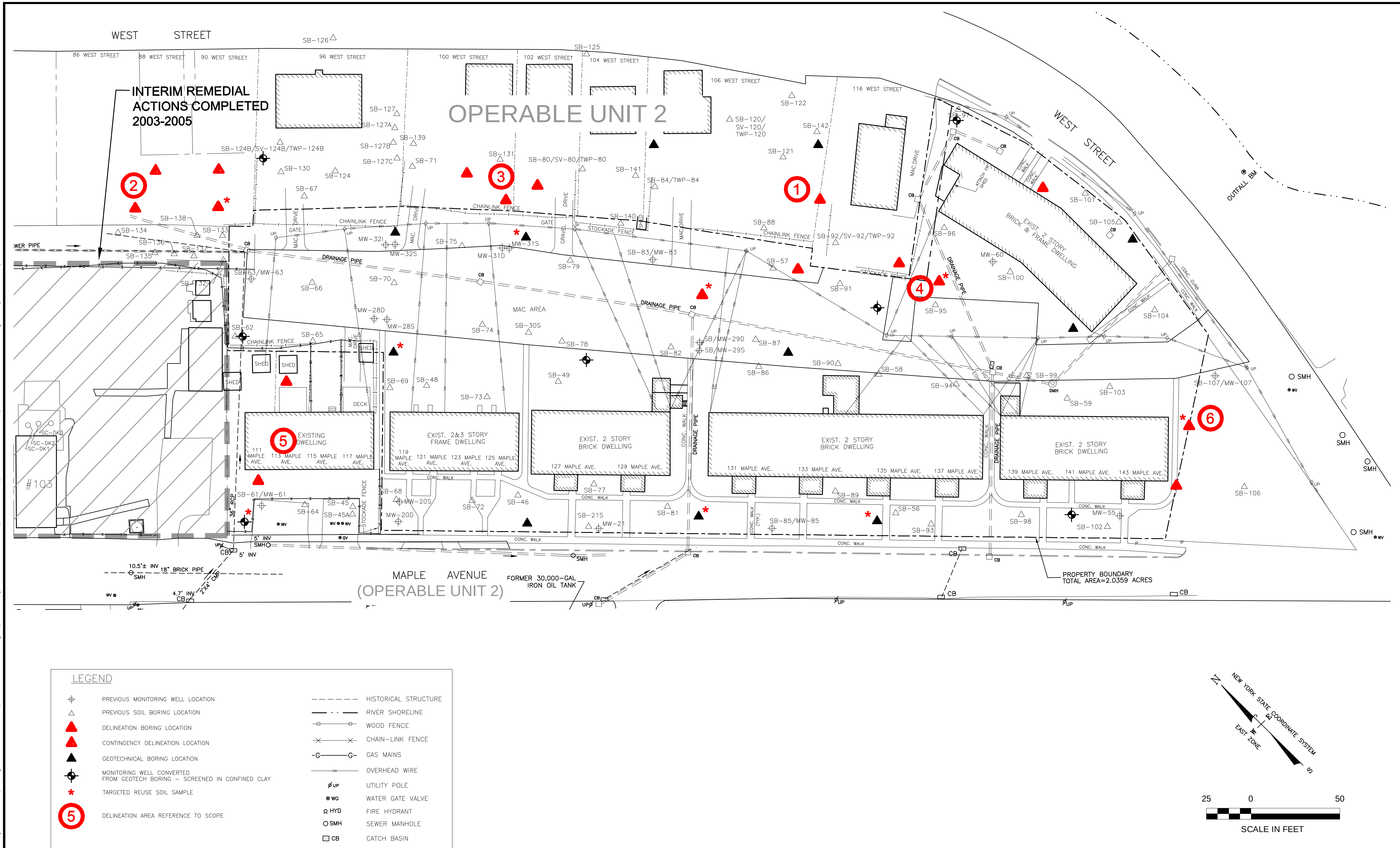
CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

DATE: 07/16/13 | DRWN: RCW

SITE LAYOUT

FIGURE 1-2



AECOM

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

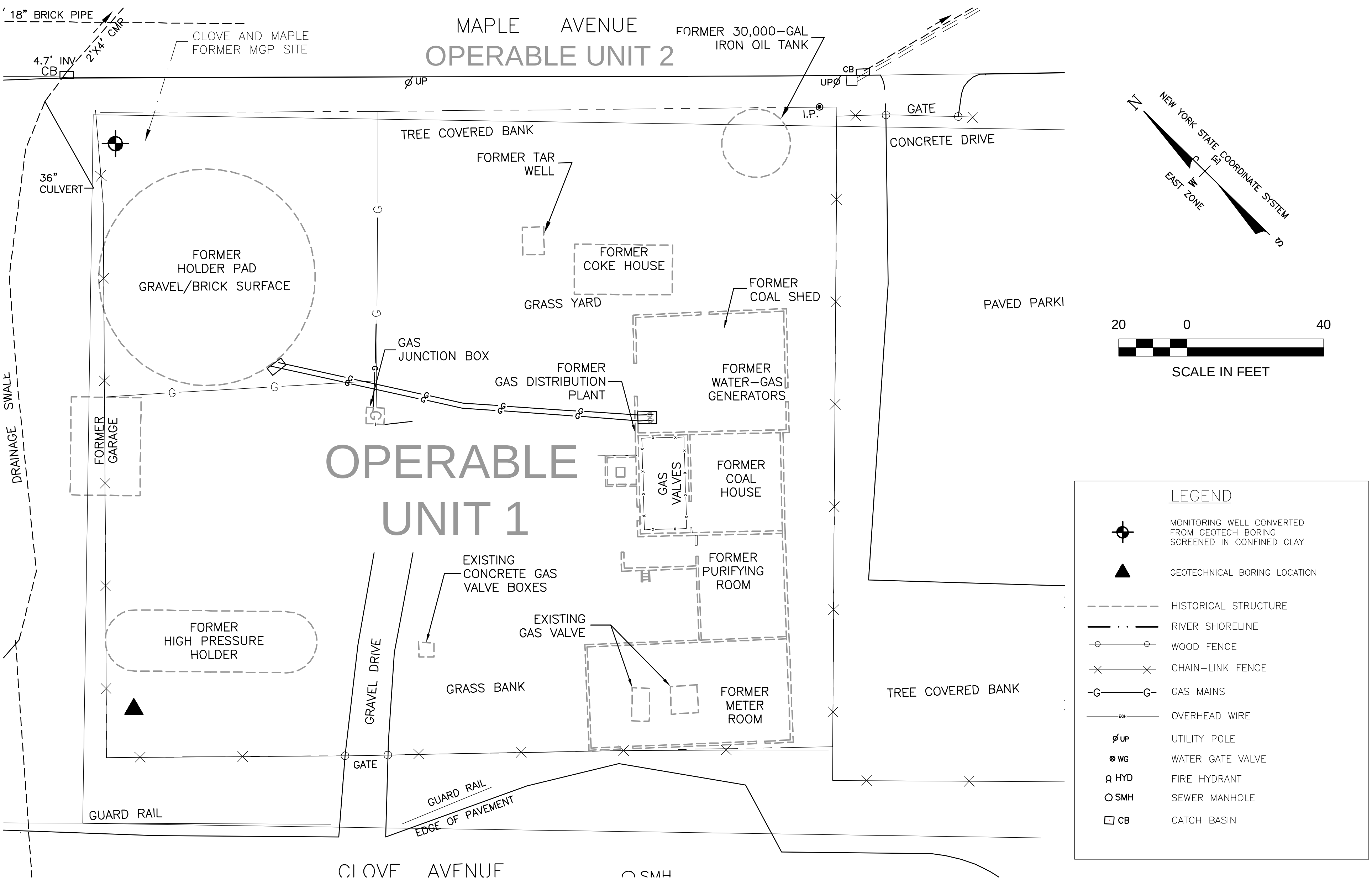
ORANGE AND ROCKLAND UTILITIES, INC.

PROPOSED BORING AND WELL LOCATIONS OPERABLE UNIT 2

DATE: 07/16/13 | DRWN: RCW

FIGURE 3-1

File: J:\Rem_Eng\Project Files\Orange & Rockland\Haverstraw Design\7.0 Project Documents\7.2 CADD\RDWP & PDIWP\60288163-C-01.dwg Layout: Prop Bor and Well Loc OU1 User: warrenr Plotted: Jul 16, 2013



AECOM

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

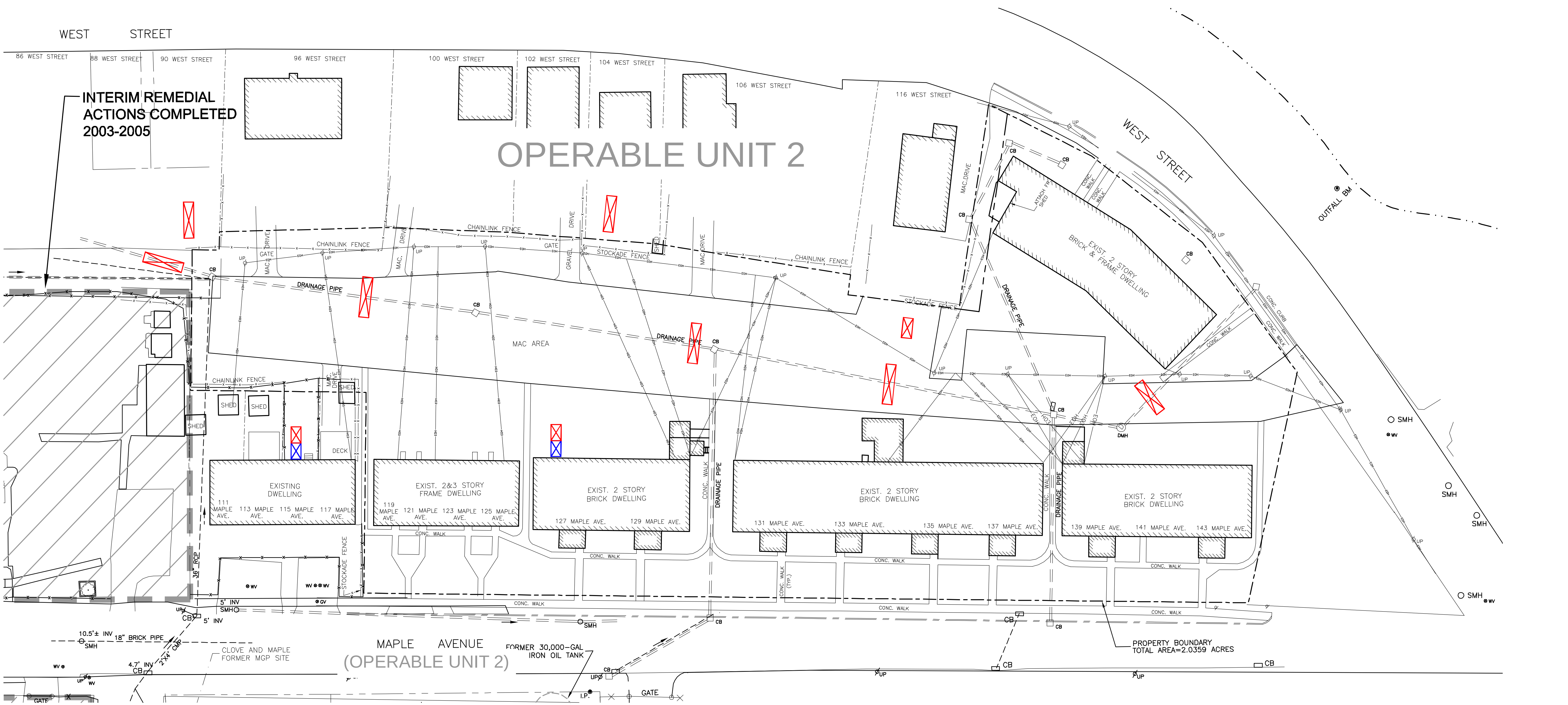
ORANGE AND ROCKLAND UTILITIES, INC.

PROPOSED BORING AND WELL LOCATIONS
OPERABLE UNIT 1

DATE: 07/16/13 | DRWN: RCW

FIGURE 3-2

File: J:\Rem_Eng\Project Files\Orange & Rockland\Haverstraw Design\7.0 Project Documents\7.2 CADD\RDWP & PDWP\60288163-C-01.dwg Layout: Test Pit Locations User: warrenr Plotted: Jul 16, 2013 - 3:03p



LEGEND

- HISTORICAL STRUCTURE
- RIVER SHORELINE
- WOOD FENCE
- CHAIN-LINK FENCE
- GAS MAINS
- OVERHEAD WIRE
- UP UTILITY POLE
- WG WATER GATE VALVE
- HYD FIRE HYDRANT
- SMH SEWER MANHOLE
- CB CATCH BASIN
- PROPOSED TEST PIT (NOT SHOWN TO SCALE)
- PROPOSED TEST PIT OWNER APPROVAL REQD. (NOT SHOWN TO SCALE)

25 0 50

SCALE IN FEET

AECOM

CLOVE AND MAPLE FORMER MGP SITE
HAVERSTRAW, NEW YORK

ORANGE AND ROCKLAND UTILITIES, INC.

DATE: 07/16/13 DRWN: RCW

PROPOSED TEST PIT LOCATIONS OPERABLE UNIT 2

FIGURE 3-3

Appendix A

Standard Operating Procedures

Description of Soil and Manufactured Gas Plant residuals

1.1 Purpose

The primary purpose of this Procedure for Describing Soil & Manufactured Gas Plant Residuals (the “Procedure”) is to provide and ensure the use of a consistent methodology for describing the materials observed in subsurface samples collected at former manufactured gas plant (“MGP”) sites. At most MGP sites, the predominant subsurface materials are native or reworked soils and fill. In some areas, however, residuals from prior MGP operations could account for a significant percentage of the overall matrix. It is also possible to encounter residual materials at the site that are unrelated to the former MGP operations. **It is critically important that all field notes and associated logs accurately represent the characteristics of the soil and MGP or other residuals as well as the proportions of soil versus residuals.**

At the same time it is also important that all field notes and logs refrain from speculation as to the origin or source of the materials being described. Proper determinations regarding the source or origin of MGP residuals or other non-native materials observed in the field requires consideration of all information at hand, including laboratory data, site history, operations at abutting properties, and other similar considerations that are unavailable and/or unknown to those conducting field work. Speculative references in field note and logs can hinder, rather than facilitate, the proper identification of the residual and therefore should be avoided. To assist in the proper determination of the origin or source of materials encountered at an MGP site, the terms and procedures delineated below should be followed. These terms and procedures were developed based upon many years of collective professional experience regarding the characteristics of MGP sites.

> **You will note that this Procedure calls for the use of descriptive terms such as “tar-like material (TLM)” and “oil-like material (OLM)”. Such terms are intended to ensure that conclusions regarding the source or origin of materials observed during sampling are based on more than simple observation.** While these terms are appropriate for field notes and logs, they should not be used in reports, unless it is absolutely necessary to describe what was observed during sampling. Instead, reports should reflect the author’s consideration of the field observations, laboratory data, site history and other available information and describe MGP residuals and other non-native materials succinctly and accurately using terms that are consistent with the source of the material (e.g., “tar”, “coal tar”, “fuel oil”, “coal tar oil”, “purifier wastes”).

This Procedure is not intended to conflict with a standard, practice or analytical method required by a regulatory agency, nor with the best professional judgment of a qualified professional. In the event that use of any part of this Procedure is perceived to conflict with an agency requirement or a qualified professional’s best professional judgment, the possible conflict must be discussed with the client and resolved prior to conducting any new or continuing any on-going site characterization work. (Field notebooks and logs should not be altered after the fact).

1.2 Key Terms for Describing MGP Residuals

It is important to note the following four characteristics when describing MGP residuals: nature of the material, color, any discernible odors, and the material's viscosity (for oil- and tar-like material). Table 1 provides a matrix of typical MGP residual ("MGPR") characteristics. Additional detail is provided below.

I. Material - when describing MGP residual material, the following terms/acronyms should be used in field notes and logs. Note that coal tar has a wide range of properties ranging from the less viscous oils (e.g. crude phenol, anthracene oil) to the highly viscous, sometimes asphaltic, pitch. The primary purpose for distinguishing oily residuals from tar in this Procedure reflects the differing potential for environmental impact.

TLM (tar-like material) - or pitch is typically a black, viscous, separate-phase material that would not be considered a fluid or ***liquid*** even though at elevated temperatures it becomes more fluid. TLM will not migrate through porous media at ambient temperatures in the subsurface, and can sometimes be asphaltic in its appearance. When encountered in the subsurface, TLM is found as a distinct, separate mass that is not interspersed within the soil matrix, although it may contain some aggregate as a result of mechanical mixing prior to or during its deposition.

OLM (oil-like material) - is non-aqueous phase liquid (NAPL) substance with varying viscosities and densities. OLM may be a petroleum product or a low viscosity substance derived from the same process that results in TLM. For purposes of field description, OLM can be distinguished from TLM based on its distribution within the soil matrix (i.e., OLM coats soil grains). OLM that exhibits MGP residual characteristics, such as odor, should be differentiated from OLM related to petroleum or other sources. The distinguishing characteristic should be identified in the field notes and log.

When describing groundwater samples use of LNAPL and DNAPL are encouraged to characterize the density of the OLM. An LNAPL (Light non aqueous phase liquid) is defined as a NAPL that floats on a waters surface because it is less dense that water, and a DNAPL (Dense non aqueous phase liquid) is defined as a NAPL that sinks in a water column because it is more dense that water. The specific gravity of OLM derived from tar is sometimes very similar to that of water (i.e., close to 1.00). The presence of an emulsified liquid should also be noted if observed in a ground water sample. An emulsion refers to a dispersion of small drops of one liquid into an immiscible liquid such as an LNAPL or DNAPL.

> **CLINKER - are agglomerated ash; clinker can be found as vesicular chunks of material that vary in size, but are typically one or two inches in diameter, and may also be produced from a variety of coal burning processes including those not related to MGP sites.**

WF (wood fibers) - this designation should be reserved for wood chips/fibers that contain blue staining, MGP residual-type odor[s], and/or infusion with OLM/TLM. Without this supporting evidence fragments of wood should be described as to the probable origin (e.g., root matter, timber, lumber, or "wood fiber, source unknown").

ASH - is a lightweight substance (relative to mineral soil) that can vary in color from white and gray to black, and may be partially combusted containing fragments of coal. This material may have a granular texture and its presence is quite often the result of coal burning associated with non-MGP sources, such as electric power generation.

II. Color - among other considerations, the color of MGP residuals (as well as the affected soil grains) can be a function of the parent material, the oxidation state, and staining. The term "staining" should be used with discretion, since it implies that only the surface of the material has the described color. Colors commonly associated with MGP residuals are:

White – this color may be indicative of lime that was sometimes used in the gas purification processes, typically at smaller MGPs. The presence of lime increases the solubility of the cyanide compounds in the immediate vicinity of the lime, so its presence in the soil column should be noted. The color white may also be attributed to the presence of ash, and hard to distinguish from lime.

Orange - this color may be indicative of high iron content, which may be inherent in the parent material, or may indicate the presence of iron-bearing, oxide box wastes.

Yellow – this color may be indicative of elemental sulfur resulting from the gas purification process. Note that reduced sulfur compounds can be black, and may be associated with organic compound odors (e.g., naphthalene). This condition can make the soil appear to be affected by OLM or TLM when it is not.

Blue - indicates the presence of ferrocyanides; sometimes this coloration is so intense that it approaches a deep purple color; when mixed with a black substance, the ferrocyanides may impart a green color to the MGP residuals, or affected soil.

Grey – ash can impart a grey color, and can be mixed with ash ranging from white to black. Coke can also be grey, with a silver appearance.

Black - this color may be due to the presence of coal fragments, soot, TLM, or OLM, or may be the color of the parent material (e.g., magnetite).

III. Odor - the three broad categories of odors that may be present at a MGP site are those associated with MGP process residuals, petroleum (often used as feedstocks for gas manufacture and/or the subsequent use of gasoline or heating fuels), and “other”. These odor categories may be further distinguished based on field experience, as indicated below.

MGP Residual Odors

- tar (hot asphalt or roofing tar)
- naphthalene (mothballs)
- styrene (sweet, fiberglass-like)
- light-end odor (akin to gasoline, but not the same)
- acrid, caustic odor (some oxide box wastes)

Petroleum Odor

- diesel/No.2 fuel oil
- kerosene
- gasoline

Other

- solvents (e.g., chlorinated compounds) or alcohols
- organic (e.g., septage, or decaying organic matter)

Odors may be very difficult to define, and will vary from person to person. If one is uncertain, classification of an odor within the three categories listed above should not be attempted.

IV. Viscosity - this characteristic is particularly important for TLM and OLM. Some TLM will begin to “flow” (e.g., assume the shape of a glass container) if exposed to sunlight or summer temperatures. Other masses of TLM are hard enough, especially when cold, that “chips” can be dislodged. Other types of TLM may be mixed with aggregate, and take on the appearance and character of asphalt pavement. Likewise, OLM found in the subsurface may exhibit various consistencies that may be indicative of “weathering”. These observations are important characteristics of TLM and OLM to note in the field logs.

V. NAPL – direct and indirect evidence of a NAPL in solid/saturated media can be obtained by careful observations, practical field screening and/or quantitative laboratory testing. The observation of NAPL, either LNAPL or DNAPL, in a collected ground water sample or the observation of NAPL released from a subsurface soil sample (e.g., core sample) are indications of the presence of a NAPL or OLM. In many cases the visual evidence is not this dramatic and it may be necessary for the scientist conducting the field logging to use some simple tests to screen a solid sample for the presence of NAPLs. These tests are described briefly below:

- "wick" test – place soil on a paper towel to see if NAPL wicks out of the sample into the paper towel
- "jar" test – place soil sample in a jar of water to see if a sheen develops, or if NAPL separates out of the soil matrix
- "Brown Paper Bag" test - place soil sample inside a brown paper lunch bag (waxed). Let sit for several minutes and observe if OLM has stained/discolored the bag. If no OLM present no discoloration will occur (water should not penetrate the light wax coating the paper).

If quantification of the percent saturation is a desired measurement, a variety of laboratory techniques can be considered:

- centrifuging of samples
- standard soil analysis
- EPRI field methods

As new technologies are developed and accepted by State and Federal agencies, the qualified professionals conducting field work for a client should discuss the process or procedure with the client before using at a site.

VI. Sheens – can be common at MGP sites, and may be apparent on soil grains, interstitial pore water, and where groundwater surfaces at seeps near drainage features. The sheen can be organic in origin, or quite often inorganic. Reducing conditions associated with the degradation of organic compounds, such as BTEX and naphthalene, can liberate inorganics native to the geologic formation (most commonly iron and manganese). Inorganic sheens can form when the reduced metals (and thus dissolved, moving with the groundwater) are exposed to aerobic conditions when groundwater discharges to surface water bodies. For example, iron bacteria that live at near-neutral pH are commonly found where ferrous iron is moving from anaerobic to aerobic conditions. These are the same types of bacteria that can cause iron fouling of pumping well screens. Discharged groundwater will often have an MGP Residual odor due to the dissolved organic compounds, so the inorganic sheen might inadvertently be attributed to separate-phase organics migrating with the groundwater.

An organic sheen occurs when the light reflected from the underlying water is refracted by a thin layer of oil, and thus the "rainbow" appearance. If disturbed, the organic sheen will coalesce, whereas the inorganic sheen "breaks" apart and has a blocky appearance.

1.3 Procedure for Subsurface Soil Logging

Sample Description Format - The basis for describing samples will be the Unified Soil Classification System (USCS), and should include the following important characteristics:

- name/modifier (e.g., gravelly sand, silty sand)
- consistency (firm, loose, plastic)
- moisture (dry, damp, moist, wet saturated)
- color
- structure (e.g., layering, fractures, no visible structure - not applicable for fill or MGP residuals)
- geologic origin, if known (e.g., till, alluvium - not applicable for fill or MGP residuals)
- odor
- viscosity (tar- and oil-like material only)

Attached is a key to the classification and description of soil using the USCS, which provides the necessary detail and a few examples. For consistency, the sequence of description should be the same as that provided in the attached examples.

Fill Material Description - In addition to native soils, fill material, which may not contain any apparent MGP residuals, is also commonly encountered at former MGPs, and may include imported soils, bricks (e.g., red clay and kiln), glass, wood timbers, and metal debris among other materials. Soils/fill may also exhibit a wide variety of colors that may be indicative of MGP residuals. Evidence of releases not associated with MGP residuals, such as petroleum releases, may also be found at MGP sites. Field descriptions should provide clear descriptions that when combined with analytical results; site history and other information will assist in distinguishing between MGP and non-MGP residuals.

Typical MGP Residuals Encountered - Soils and fill at former MGP sites may contain varying amounts and types of MGP residuals depending on the years of operation and the types of processes used to generate and purify the gases. As discussed above, the types of MGP residuals commonly encountered include the following.

- Ash
- TLM - tar-like material
- OLM - oil-like material
- Clinker
- WF - wood fibers that are heavily blue stained or contain other MGP residuals
- coal or coke fragments

In most instances, subsurface samples are comprised primarily of soil, which may contain various proportions of MGP residuals. Field notes should accurately document the percentage of MGP residuals in a sample (e.g., 85% gravelly sand, 10% clinker, and 5% ash), and the distribution of MGP residuals within the sample (e.g., a two-inch seam of ash).

When describing MGP residuals it is important to base the description on **appearance** (e.g., black, highly-viscous, TLM containing no appreciable aggregate) and **not** the assumed source (e.g., black tar from the former tar & liquor tank). Although the sample description should be based on appearance only, additional notation regarding the location of the sample is desirable. For example, an abundance of MGP residuals exposed in a test pit may be indicative of source material, whereas the presence of MGP-related constituents remote from any known source may be an indication of MGP residuals mobility (e.g., blue-stained, native soils found at depth in a soil boring). Therefore, field descriptions should allow the reader to clearly distinguish between fill materials and native soils affected by compound migration.

1.4 Procedure for Logging Sediment and Seeps

[Note: The Procedure currently does not specifically address sediment and seeps. Much of the interest in seeps is covered by the discussion of Key Term VI – Sheens; however, additional thoughts are requested on characterizing seeps in the field. For describing predominantly granular sediment, the USCS is one option. For MGPs that are situated near bodies of water, most are located near rivers, where sediment is typically comprised of mineral (i.e., granular) deposits. More quiescent settings (e.g., ponds, slow moving streams) may be dominated by organic deposits, which are less amenable to description using the USCS. The only option for organic soils under the USCS is Peat (Group Symbol: Pt). Additional thoughts are being solicited for describing sediment dominated by organic deposits and the guidance will be updated to reflect appropriate guidance for sediment logging.]

KEY TO CLASSIFICATION AND DESCRIPTION OF SOIL

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			Group Symbol	Typical Name
COURSE-GRAINED SOIL (>50% retained on # 200 sieve)	GRAVEL (>50% of coarse fraction retained on # 4 sieve)	Fines <5%	**GW**	Gravel, well graded
			GP	Gravel, poorly graded
		Fines 5-12%	**GW-GM** **GW-GC**	Gravel, well graded
			GP-GM **GP-GC**	Gravel, poorly graded
		Fines >12%	**GM** **GM-ML** **GM-MH**	Silty gravel
			GC **GC-CL** **GC-CH**	Clayey gravel
	SAND (≥50% of course fraction passes #4 sieve)	Fines < 5%	**SW**	Sand, well graded
			SP	Sand, poorly graded
		Fines 5-12%	**SW-SM** **SW-SC**	Sand, well graded
			SP-SM **SP-SC**	Sand, poorly graded
		Fines >12%	**SM** **SM-ML** **SM-MH**	Silty Sand
			SC **SC-CL** **SC-CH**	Clayey sand

FINE-GRAINED SOIL (≥50% passes #200 sieve)	CHARACTERISTICS OF FRACTION PASSING #40 SIEVE					
		DRY STRENGTH (crushing charac-teristic)	DILATENCY (reaction to shaking)	TOUGHNESS (consistency near plastic limit)		
	Liquid limit <50	None to slight	Quick to slow	None	**ML**	Silt, nonplastic to slightly plastic
		Medium to high	None to very slow	Medium	**CL**	Clay, nonplastic to slightly plastic
		Slight to medium	Slow	Slight	OL	Organic silt or silt-clay nonplastic to slightly plastic
	Liquid limit >50	Slight to medium	Slow to none	Slight to medium	**MH**	Silt, moderately to highly plastic
		High to very high	None	High	**CH**	Clay, moderately to highly plastic
		Medium to high	None to very slow	Slight to medium	**OH**	Organic clay, moderately to highly plastic
Highly organic soil	Decaying vegetation				**Pt**	Peat
Minor Constituents	0-10% Trace	10-20% Little	20-35% Some	**35-50% And**		

SOIL DESCRIPTIONS

Name/modifier, gradation (beginning with coarsest fraction) or plasticity, consistency, moisture content, color, structure (as appropriate), geologic origin or formation name (if known), USCS group symbol

Examples:

Gravelly sand, well graded, 15-20% gravel to 1-inch maximum, medium to coarse sand, <5% fines, dense, moist, light yellowish brown, stratified, glacial outwash (SW)

Sandy silt, nonplastic, 5-10% subangular gravel to 1.5 inch maximum, 20-30% fine to coarse sand, very dense, damp, dark olive gray, occasional root molds, till (ML)

DENSITY / CONSISTENCY (BASED ON SPT BLOW COUNTS)

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
Descriptor	Blows/foot	**Descriptor**	**Blows/foot**
Very loose	0 to 4	Very soft	0 to 2
Loose	5 to 10	Soft	2 to 4
Medium dense	11 to 30	Firm	4 to 8
Dense	31 to 50	Stiff	8 to 15
Very dense	>50	Very stiff	15 to 30
		Hard	>30

MOISTURE CONTENT

↑ ↑ ↑ ↑ Wetter ↑ ↑ ↑ ↑

SATURATED

WET

MOIST

DAMP

DRY

TABLE 1 - TYPICAL CHARACTERISTICS OF MGP RESIDUALS

MGP Residual	Matrix Description	Color	Odor	Moisture Content/ Viscosity
ASH	a lightweight substance with a texture that varies from clay-like to a gritty, sometimes granular material depending on the degree of combustion (may contain coal fragments)	typically black, sometimes white or grey	very little; may take on odors of other MGPR in the area	typically dry, unless moistened due to soil water or OLM, TLM, etc.
TLM	viscous material that resembles roofing tar	typically a dark black	similar to asphalt or driveway sealer	many types of TLM will “flow” (e.g., take on the shape of a container); the viscosity will vary depending on its moisture content and the amount of aggregate mixed into the TLM prior to disposal
OLM	dark liquid substance that resembles fuel oil	typically dark amber to black; may be light colored to clear	similar to TLM, but the presence of lighter PAHs (commonly naphthalene) and other aromatics are more apparent	highly variable; can range from a viscosity that is similar to water, or to that of No. 2 , 4, or 6 fuel oil
CLINKER	vesicular, sometimes glass-like and lightweight; pebble to cobble sized	brown to grey; glossy	very little; may take on odors of other MGPR in the area	typically dry, unless moistened due to soil water
WF	chips or fibers of wood typically “cemented” into blocky masses	brown to black, or bright blue; orange	depends on the degree of OLM/TLM saturation; dry material exhibits acrid odor; moist material may have TLM odor	typically dry, unless moistened due to soil water, or OLM/ TLM presence.

SOP NUMBER: 7115

Subsurface Soil Sampling by Split Spoon

Date:	3rd Qtr. 1994
Revision Number:	3
Author:	Charles Martin
Discipline:	Geosciencies

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods used in obtaining subsurface soil samples for physical and/or chemical analysis. Subsurface soil samples are obtained in conjunction with soil boring programs and provide information as to the physical and/or chemical makeup of the subsurface environment.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling by split-spoon only, as this is the means most often used for obtained samples of unconsolidated deposits. Other types of equipment are available for use in subsurface soil sampling, including thin-wall tube samplers (Shelby tubes), piston samplers, and continuous core barrel samplers. Information on the use of these other sampling devices may be found in several available drilling handbooks and respective state and/or federal agency technical guidance documents. The American Society for Testing and Materials (ASTM) also provides procedures for use of split-spoon and other sampling devices.

Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Split-spoon subsurface soil sampling generally requires use of a drilling rig and typically the hollow-stem auger or other common drilling method to generate a borehole in which to use the split-spoon sampler. The split-spoon sampler is inserted through the augers (or other type of drill casing) then is driven into the subsurface soil with a weighted hammer. The sampler is then retrieved and opened to reveal the recovered soil sample. Soil samples may be collected at a continuous interval or at pre-selected vertically spaced intervals within the borehole.

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

1.4 Health and Safety Considerations

Subsurface soil sampling may involve chemical hazards associated with the types of contaminants potentially encountered and will always involve potential physical hazards associated with use of drilling equipment. When sampling is performed in materials which may contain hazardous constituents, or when the quality assurance objectives of the project require the use of hazardous solvents, adequate Health and Safety measures must be taken to protect sampling personnel. These measures must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Drilling Subcontractor

It will be the responsibility of the drilling subcontractor to provide the necessary materials for obtaining subsurface soil samples. This generally includes one or more split-spoon samplers in good operating condition and sample containers used for stratigraphic characterization samples (sample containers for environmental samples should be provided by the designated analytical laboratory). It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be supplied by the subcontractor and should meet project specifications.

2.2 Project Geologist/Sampling Engineer

It will be the responsibility of the project geologist/sampling engineer to conduct subsurface soil sampling in a manner which is consistent with this SOP. The project geologist/sampling engineer will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the project geologist/sampling engineer's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The project geologist/sampling engineer is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labeling, handling, and storage of samples until further chain-of-custody procedures are implemented.

3.0 REQUIRED MATERIALS

In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Project Sampling Plan, QAPP, and HASP
- Boring logs
- Teaspoon or spatula (stainless steel is recommended)
- Sample kit (bottles, labels, custody records and tape, cooler)
- Sample collection pen
- Folding rule or tape measure
- Equipment decontamination materials
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

4.0 METHOD

4.1 General Method Description

Split-spoon sampling devices are typically constructed of steel and are most commonly available in lengths of 18 and 24 inches and diameters of 1.5 to 3 inches. The split-spoon consists of a tubular body with two halves that split apart lengthwise, a drive head on the upper end with a ball-check valve for venting, and a hardened steel cutting shoe at the bottom. The soil sample enters the split-spoon through the cutting shoe as the device is driven into the ground. A replaceable plastic or metal basket is often inserted into the shoe to assist with retaining samples. Once the sampler is retrieved, the drive head and cutting shoes are removed and the split-spoon halves are then separated, revealing the sample.

Sample depth intervals are usually defined on a project-specific basis with these requirements specified in the project sampling plan. Sampling intervals typically range from one (1) sample per five (5) feet of drilling to continuous sampling where the entire drilled interval is sampled.

Subsurface soil sampling is usually accomplished as part of a drilling program where a soil boring is advanced with drilling equipment to the designated depth prior to collection of a representative sample. The general procedures outlined briefly in the following section provide requirements for advancing drill casing/augers in preparation for sampling.

4.2 General Procedures - Borehole Preparation

4.2.1 Advancing Casing/Augers

Soil borings that are completed for soil sampling purposes are typically advanced using hollow-stem augers and sometimes drive-and-wash or other casing methods. The casing/augers must be of sufficient diameter to allow for soil sampling at a minimum. The casing/augers will be advanced according to project requirements to the required depth for sampling. If hollow-stem augers are used, a temporary plug shall be used in the lead auger to prevent the auger from becoming filled with drill cuttings while drilling is in progress.

4.2.2 Obstructions

For those borings which encounter obstructions, the casing/augers will be advanced past or through the obstruction if possible. Caution should be exercised when obstructions are encountered and an effort made to identify the obstruction before drilling is continued. If the obstruction is not easily drilled through or removed, the boring should be relocated to an adjacent location.

4.2.3 Use of Added Water

The use of added or recirculated water during drilling is permitted when necessary. Use of extraneous water should be minimized or avoided if possible as it may impact sample quality. Water usage should be documented in the field notebook. Sampling and analysis of added or recirculated water may be required for quality assurance purposes (refer to QAPP). If a well is installed within the completed borehole, removal of the added water may be required.

4.3 Sampling Procedure

4.3.1 Equipment Decontamination

Each split-spoon must be decontaminated prior to its initial use and following collection of each soil sample. Site-specific requirements for equipment decontamination should be outlined within the Project Sampling Plan. Equipment decontamination procedures are also outlined within SOP 7600 - Decontamination of Equipment.

4.3.2 Standard Penetration Test

The drilling subcontractor will lower the split-spoon into the borehole. Samples are generally obtained using the Standard Penetration Test (SPT) in accordance with ASTM standards (ASTM D 1586-84). Following this method, the sampler will be driven using the 140-pound hammer with a vertical free drop of 30 inches using two turns of the rope on the cathead. The number of hammer blows required for every 6 inches of penetration will be recorded on the boring log. Blowcount information is used as an indicator of soil density for geotechnical as well as stratigraphic logging purposes. Once the split-spoon has been driven to its fullest extent, or to refusal, it will be removed from the borehole.

4.3.3 Sample Recovery

The split-spoon will be immediately opened upon removal from the casing/auger. The open sampler shall then be screened for volatile organics with a photoionization device (PID) if required by the Project Sampling Plan. If the Sampling Plan also requires individual soil sample headspace screening for volatile organic compounds, then a small portion of the split-spoon sample shall be removed and properly contained for that purpose.

Sample recovery will be determined by the project geologist/sampling engineer who will examine the soil core once the sampler is opened. The length of sample shall then be measured with a folding rule or tape measure. Any portion of the split-spoon contents which are not considered part of the true sample (i.e., heaved soils) will be discarded. If the sample recovery is considered inadequate for sample characterization or analytical testing purposes, another sample should be collected from the next vertical interval if possible before drilling is reinitiated.

Adequate sample recovery for stratigraphic logging purposes and/or headspace organic vapor testing purposes should be approximately 6 inches. Adequate sample recovery for analytical testing purposes should be a minimum of 12 inches and is somewhat dependent on the type of analytical testing required. In some cases, continuous sampling over a short interval, and compositing of the sample, may be required to satisfy analytical testing requirements. Larger diameter samplers may be used if large volumes of soil are required for analytical testing.

4.3.4 Sample Containment - General

Once retrieved, the sample will be removed from the split-spoon with a teaspoon or spatula and placed into the appropriate sample container. The sample will be split if necessary to meet sampling program requirements. Sample splitting may be necessary to provide individual samples for headspace testing, visual characterization, physical testing, analytical testing, or simply for archiving purposes. In general, most sampling programs are structured around environmental characterization needs; therefore, sample portions required for analytical testing should be collected first. The Project Sampling Plan and QAPP provides specific sample container requirements for each type of sample and should be referred to for guidance.

Once filled, the sample containers should be properly capped, cleaned, and labeled, and chain-of-custody and sample preservation procedures initiated. Sampling equipment should then be properly decontaminated.

4.3.5 Sample Containment - Volatile Organic Analyses

Collection of subsurface soil samples for volatile organic analysis (VOA) is slightly more complex than collection of samples for other routine chemical or physical testing primarily because of the concern for the potential loss of volatiles during the sample collection procedure. To limit the potential for loss of volatiles, the soil sample needs to be obtained as quickly and as directly as possible from the split-spoon. This generally means that the VOA sample is to be collected and placed into the appropriate sample container first. The VOA sample should also be obtained from a discrete portion of the entire sample interval and not composited or homogenized. The remainder of the recovered sample can then be composited, homogenized or split to meet the other testing requirements. The boring log and/or sample logbook should be filled out to indicate actual sample collection depths for both VOA samples and other portions of the sample which may have been composited over a larger vertical interval.

5.0 QUALITY CONTROL

Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs
- Field log books
- Sample collection records
- Chain-of-custody records
- Shipping labels

Boring logs (Figure 1) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a sampling program. The field log book is kept as a general log of activities. Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original copies of these records should be maintained in the appropriate project files.

7.0 REFERENCES

ASTM D 1586-84

Figure 1

Sheet 1 of __

BORING LOG

Project No. ____ Date – Start ____ Finish ____ Boring ____

Project Name ____ Drilling Co. ____

Location ____ Drilling Method ____

Total Depth ____ Inspector ____ Reviewer ____

Remarks ____

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 in.	Depth Range	Rec.			

SOP NUMBER: 7116

Subsurface Soil Sampling by Geoprobe™ Methods

Date:	2nd Qtr. 1995
Revision Number:	0
Author:	Charles Martin
Discipline:	Geoscience

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods available for collecting subsurface soil samples using commercially available Geoprobe™ Systems (or other similar vendor) soil probing equipment. Subsurface soil samples may be obtained using this system for purposes of determining subsurface soil conditions and for obtaining soil samples for physical and/or chemical evaluation.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples using the Geoprobe™ system. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling using Geoprobe™ Systems equipment; specifically, the Macro-Core Soil Sampler, and the Large Bore Sampler. Use of this sampling equipment requires use of the Geoprobe™ hydraulically-powered percussion/probing machine. Geoprobe™ sampling is usually performed by subcontractors, although rental equipment is available for use by trained operators.

The Geoprobe™ sampling methods covered in this SOP are applicable to unconsolidated soil/fill materials and to a maximum recommended depth of approximately 30 feet. Sampling depths are greatly dependent upon soil density as the hydraulically-powered probing unit has power limitations. Sample recovery is also somewhat dependent on grain size as very coarse gravel, cobbles, and boulders will occasionally cause premature refusal of the sampler. It is generally preferable to have some prior knowledge of site soil conditions if sampling activities are proposed where equipment limitations may become a factor.

Other types of equipment and sampling methods are available for use in obtaining samples of unconsolidated materials; and include split-spoons, Shelby tubes, and continuous core barrel samplers. Information on these and other soil sampling devices may be found in other AECOM SOPs, ASTM procedures, drilling handbooks, and respective state and/or federal agency technical guidance documents.

1.2 General Principles

Soil sampling using the Geoprobe™ System requires use of the hydraulically-powered percussion/probing machine and either the Macro-Core Soil Sampler or the Large Bore Sampler soil sampling devices. The percussion/probing machine is typically mounted onto the bed of a pickup truck or van so that a stable working platform is established. The percussion/probing machine, through its hydraulic operation, pushes and hammers the soil sampling equipment vertically into the ground within the targeted sampling interval. The soil sampler is then extracted from the ground to recover the sample.

The Macro-Core Sampler (Figure 1) consists of a 45-inch long by 1.5-inch diameter open-ended steel sampling tool with liners made of clear plastic (cellulose acetate butyrate), stainless steel, or teflon. The tool is designed for use in a continuous sampling capacity in an open borehole up to depths of approximately 24 feet. The borehole walls are required to stay open in order to collect a sample from the next depth interval. Once the sampling tool is removed from the ground, the inserted liner containing the soil sample is removed from the tool. The soil sample is then cut from or extracted from the liner. This sampling tool is most often used for soil profiling and collection of larger volume soil samples (1,300 ml).

The Large Bore Sampler (Figure 2) consists of a 22-inch long by a slightly over 1-inch diameter steel sampling tool and may be used for sampling to depths of approximately 30 feet. Various liner types are available for use with this sampler, and include: plastic, brass, stainless steel, and teflon. The metal liners are available in segmented 6-inch lengths. The sampler is designed for discrete interval sampling and is not affected significantly by borehole wall collapse. This sampler is similar to a piston sampler where a retractable drive (piston) point is withdrawn when the targeted sampling interval is achieved and the soil sample enters the sampler. Once the sampler is removed from the ground, the inserted liner containing the soil sample is extracted from the sampler and the soil sample is then cut from or extracted from the liner. The segmented liner materials and discrete interval sampling capability gives this device greater suitability for collection of smaller volume soil samples (320 ml).

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

1.4 Health and Safety Considerations

The health and safety considerations for the site, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP). All field activities will be conducted in conformance to this HASP. In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 Project Geologist/Engineer

It will be the responsibility of the project geologist/sampling engineer to conduct subsurface soil sampling in a manner which is consistent with this SOP. The project geologist/sampling engineer will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the project geologist/sampling engineer's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The project geologist/sampling engineer is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labeling, handling, and storage of samples until further chain-of-custody procedures are implemented.

2.2 Drilling Subcontractor

It will be the responsibility of the drilling subcontractor to provide the necessary Geoprobe™ equipment for obtaining subsurface soil samples. This generally includes the truck or ATV-mounted percussion/probing machine and one or more Macro-Core and Large Bore samplers in good operating condition, appropriate liners, and other necessary equipment for borehole preparation and sampling. It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be provided by the subcontractor and should meet project specifications.

3.0 REQUIRED MATERIALS

In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Project Sampling Plan, QAPP, and HASP
- Boring Logs
- Teaspoon or spatula
- Sample kit (bottles, labels, custody records and tape, cooler)
- Sample collection pan
- Folding rule or tape measure
- Utility knife
- Equipment decontamination materials (as required by QAPP)
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

Sampling equipment which comes in direct contact with environmental samples during the sample collection process should be constructed of stainless steel, teflon, or glass, unless specified otherwise in the Project Sampling Plan or QAPP.

4.0 METHOD

4.1 General Method Description

Geoprobe™ soil sampling methods generally involve collection of soil samples by driving the sampling tool directly into the ground using the percussion/probing machine and without the aid of hollow-stem augers or other casing-installed drilling methods. Both the Macro-Core and Large Bore soil samplers consist of metal tubes of seamless construction which can not be split apart like split-spoons. Liner/sleeve inserts are required in order to extract an intact soil core/sample from the sampling device.

Both sampling devices operate by being directly pushed/hammered into the ground by the percussion/probing machine. The borehole is created as the sampling device is advanced downward. The Macro-Core Sampler collects samples continuously and requires that an open borehole be maintained for efficient sample recovery. The Large Bore Sampler contains a piston tip/drive point which allows for advancing the sampler to a designated depth for discrete interval sampling. The piston tip is retracted when the desired sampling interval is reached.

When the soil sampling device is retrieved from the borehole, the drive head, cutting shoe and/or piston assembly is removed, and the liner insert with sample is removed from the sampling device. The project geologist/sampling engineer is then given access to the sample for whatever purpose is required.

Table 1 summarizes the construction characteristics and sampling attributes of each type of sampler. The appropriate type of sampler should be selected based on project-specific sampling requirements.

4.2 Equipment Decontamination

Each sampling device must be decontaminated prior to its initial use and following collection of each soil sample, especially if sampling for analytical testing purposes is conducted. If sampling for soil logging only is conducted, thorough sampler decontamination between samples may not be necessary although sufficient cleansing is necessary for the sampler to operate properly. Site-specific requirements for equipment decontamination should be outlined in the Project Sampling Plan. Equipment decontamination procedures are also outlined within SOP 7600 - Decontamination of Equipment.

4.3 Sampling Procedures - Macro-Core Sampler

(Note: These procedures are excerpted from Geoprobe™ Systems literature. This SOP assumes that the subcontractor will perform sampling; therefore, detailed procedures regarding sample aquisition are not provided.)

4.3.1 Sampler Preparation

- Decontaminate the sampler parts (cutting shoe, sample tube, liners) before assembly.
- Assemble the sampler by first placing the liner over the inside end of the cutting shoe, then inserting the liner/shoe assembly into the sample tube, and then finally threading the cutting shoe into the sample tube. Tighten the cutting shoe with the shoe wrench.
- Thread the sampler onto the drive head.

4.3.2 Sampling

- Using the percussion/probing machine, drive the sampler into the ground until the drive head reaches the ground surface.
- For deeper samples, the borehole walls must remain stable. The cutting shoe is designed with a tapered surface to limit sidewall scraping. Add additional probe rods until the sampler reaches the

targeted sample interval, then drive the sampler through the desired sample interval.

- Use the machine hydraulics to pull the sampler from the borehole.

4.3.3 Sample Recovery

- Once the sampler has been removed from the borehole, the sampler must be unthreaded from the drive head, the cutting shoe unthreaded from the sampler, and the liner/shoe assembly removed from the sample tube.

- Disconnect the cutting shoe from the liner which contains the soil sample. The recovered soil sample may now be viewed, logged, and extracted from the liner for analysis (refer to Section 4.5 for sample containment procedures).

4.4 Sampling Procedures - Large Bore Sampler

(Note: These procedures are excerpted from Geoprobe™ Systems literature. This SOP assumes that the subcontractor will perform sampling; therefore, detailed procedures regarding sample aquisition are not provided. Additional detailed sampling procedures for this specific item of equipment is presented in Geoprobe™ Technical Bulletin No.93-660, appended to this SOP.)

4.4.1 Sampler Preparation

- Decontaminate the sampler parts (cutting shoe, piston rod/tip, sample tube, liners) before assembly.

- Assemble the sampler by first placing the liner on the cutting shoe, then threading the liner/shoe assembly into the sample tube, then connecting the piston tip to the piston rod, and then finally inserting the piston tip/rod assembly into the sample tube. Tighten the cutting shoe with the shoe wrench.

- Thread the sampler onto the drive head. Thread the stop-pin onto the drive head (stop-pin holds the piston tip/rod in place while driving the sampler to the desired sample interval).

4.4.2 Sampling

- Using the percussion/probing machine, drive the sampler into the ground until the upper portion of the targeted sampling interval is achieved.

- Unthread and remove the stop-pin from the drive head using extension rods. This will activate the piston tip/rod.

- Drive the sampler through the targeted sampling interval to collect the sample. The piston tip/rod will retract as the sample enters the sample tube.

- Use the machine hydraulics to pull the sampler from the ground.

4.4.3 Sample Recovery

- Once the sampler has been removed from the ground, the sampler must be unthreaded from the drive head, then the cutting shoe unthreaded from the sample tube, and the liner/shoe assembly removed from the sample tube.

- Disconnect the cutting shoe from the liner which contains the soil sample. The recovered soil sample may now be viewed, logged, and extracted from the liner for analysis (refer to Section 4.5 for sample containment procedures).

4.5 Sample Containment

4.5.1 General

- The soil sample can be removed from the liner following viewing and/or logging. Non-segmented plastic or teflon liners should be cut with a utility knife into approximate 6-inch lengths to facilitate sample extraction or to isolate specific sample zones targeted for analysis. Segmented metal liners can be manually separated.

- Once the liner has been separated, the soil sample may be extracted from the individual liner segments with a spoon or spatula. Except for volatile organic samples (see below), the soil sample should be placed into a sample collection pan and homogenized. Place the sample directly into the required sample container.

- Once filled, the sample container should be properly capped, cleaned and labeled. Sample chain-of-custody and preservation procedures should then be initiated.

- Perform equipment decontamination following containment of the sample.

4.5.2 Volatile Organic Samples

- Use of teflon liners is preferred when sampling for analysis of volatile organic compounds (VOC) because these liners are more inert. In order to limit the potential for loss of volatiles, the soil sample should be removed from the liner as soon as possible after sample recovery. VOC soil samples should be selected from a central point within the liner unless another specific sample zone has been targeted. The liner should be cut with a knife and the sample immediately extracted and containerized. Clean and label the container and place it into a cooler immediately. Residual sample may then be used to fill other sample or logging requirements.

5.0 QUALITY CONTROL

Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for equipment decontamination (frequency and materials), sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs
- Field log books
- Sample collection records
- Chain-of-custody records
- Shipping labels

Boring logs (Figure 3) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a soil sampling program. The field log book is kept as a general log of activities and should not be used in place of the boring log. Occasionally, sample collection records are used to supplement boring logs, especially for environmental samples which have been collected for laboratory analysis. Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original copies of these records should be maintained in the appropriate project files.

7.0 REFERENCES

Geoprobe™ Systems, August 1993, "1993-94 Equipment and Tools Catalog".

TABLE 1
Geoprobe Systems Soil Sampler Characteristics

Sampler Type	Length (in.)	Diameter (in.)	Volume (ml)	Sleeve Liner Type	Suitability[1]			
					Soil Logging	Physical Testing	Chemical-Inorganics	Chemical-Organics
Macro-Core	45	1.5	1,300	Acetate Stainless Steel Teflon	A B A	A A A	A B A	B A A
Large Bore	22	1.06	320	Acetate Brass Stainless Steel Teflon	A B B A	A A A A	A B B A	B B A A

[1] **A - Preferred suitability**
B - Acceptable suitability

Figure 1 – Soil Sampling Tools – Macro-Core Sampler - Parts

SOIL SAMPLING TOOLS - Macro-Core Sampler - Parts

Macro-Core Sampler

AT-720 Series

The sampler features a nickel-plated sample tube that is 48" long x 2.0" in diameter, a hardened tool steel cutting shoe that has a 1.5" diameter opening, and a tapered drive head that fits standard Geoprobe probe rods. The overall length assembled is 51.25". Sample recovery is 45" long x 1.50" diameter (1302 ml) in a PETG liner.

PARTS

AT-720 MC Cutting Shoe
AT-721 MC Drive Head
AT-722 MC Sample Tube
AT-725 MC PETG (clear plastic) Liner
AT-726 MC Vinyl End Cap
AT-727 MC Shoe Wrench

KITS

Assembled Macro-Core Sampler*
Part No. AT-720K
Includes the following parts:
(1) **AT-720** MC Cutting Shoe
(1) **AT-721** MC Drive Head
(1) **AT-722** MC Sample Tube
*kit does not include liners and end caps

LINERS

AT-725K MC PETG Liners (pre-flared, clear plastic) Box of 66 only
AT-726K MC Vinyl End Caps (fit AT-725 liners) Box of 66 pairs (66 red/66 black)

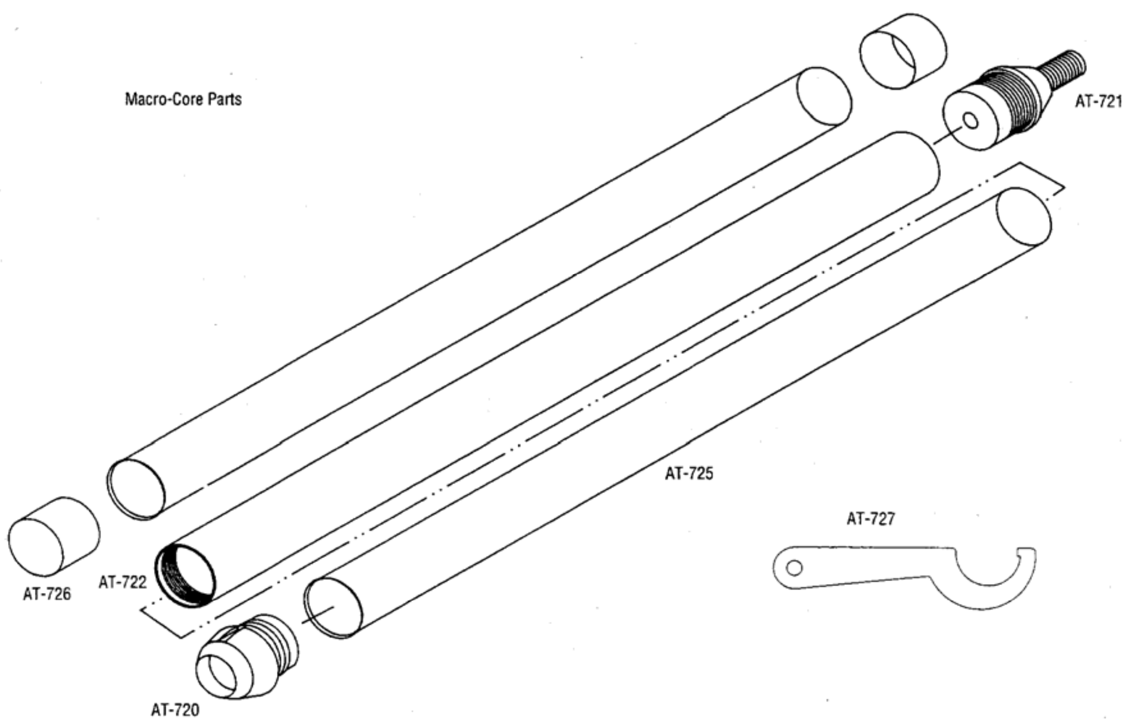


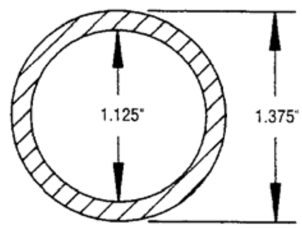
Figure 2 – Soil Sampling Tools – Probe Drive System/Large Bore

SOIL SAMPLING TOOLS - Probe Drive System/Large Bore

Large Bore Sampler

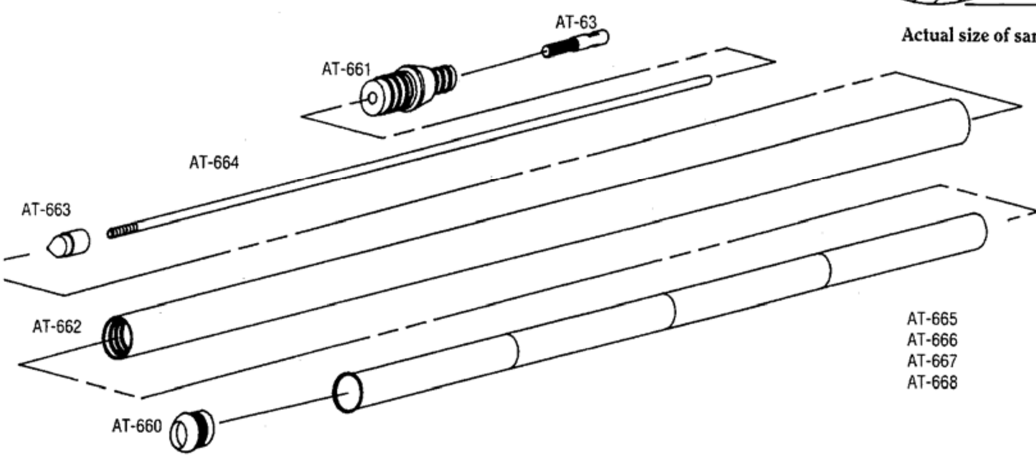
AT-660 Series

Features nickel plated sample tube, replaceable hardened tool steel cutting shoe and removable liner. Recovers core approximately 22" long x 1-1/16" diameter (320 ml). Uses STD Piston Stop-Pin. Recommended for sampling depths up to 30 feet. Liners available in brass, stainless steel, PTFE (Teflon), or PETG (clear plastic).



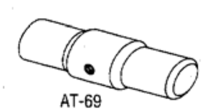
Actual size of sample tube

Large Bore Sampler Parts:



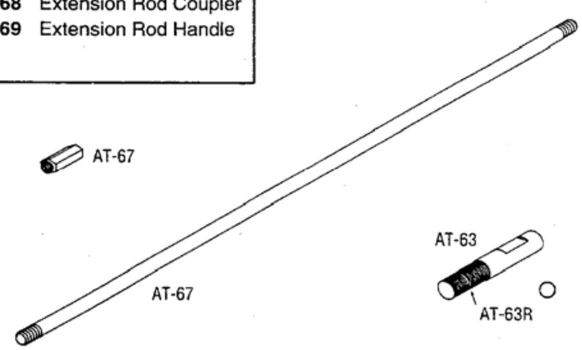
PARTS

Large Bore Sampler Parts		Liners		Also required:	
AT-660	LB Cutting Shoe	**AT-665**	LB PETG Liner	**AT-63**	STD Stop-Pin
AT-661	LB Drive Head	**AT-666**	LB Brass Liner	**AT-63R**	Stop-Pin O-rings
AT-662	LB Sample Tube	**AT-667**	LB Stainless Liner	**AT-67**	Extension Rod
AT-663	LB Piston Tip	**AT-668**	LB PTFE Liner	**AT-68**	Extension Rod Coupler
AT-664	LB Piston Rod			**AT-69**	Extension Rod Handle
AT-669	LB Shoe Wrench				



PARTS

Parts used with all Probe-Drive Samplers	
AT-63	STD Stop-Pin
AT-63R	Stop-Pin O-rings
AT-67	Extension Rod
AT-68	Extension Rod Coupler
AT-69	Extension Rod Handle



Extension Rod Parts

Stop-Pin Parts

Geoprobe Systems

Figure 3 – Boring Log

BORING LOG

Sheet 1 of

Project No. ______ Date - Start ______ Finish ______ Boring ______

Project Name ______ Drilling Co. ______

Location ______ Drilling Method ______

Total Depth ______ Inspector ______ Reviewer ______

Remarks ______

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			

SOP NUMBER: 7230	
Test Pits/Trench Subsurface Exploration	**Date:** October 2002 **Revision Number:** 2 **Author:** Scott Olson **Discipline:** Geosciences

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods for excavating and logging test pits or trenches. Test pits/trenches are generally excavated to visually determine subsurface soil and rock conditions and for environmental sampling. Test pits/trenches are generally excavated by a qualified subcontractor under the direction of the project geologist.

The purpose of this SOP is to provide a specific method and/or procedure to be used for test pit excavation, soil sample collection, and test pit logging. If followed properly, use of this SOP will promote consistency in each of the above areas.

This SOP is applicable to test pit/trench excavations which are usually completed with a backhoe. Test pits/trenches are generally completed to shallow depths (up to 10 feet approximately), and usually within unconsolidated materials, including but not limited to, native materials (sand, gravel, silt, clay), fill materials, and weathered bedrock.

1.2 General Principles

Test pit/trench subsurface explorations generally involve use of backhoes to perform excavations for the purpose of visually assessing subsurface soil/fill conditions and to allow for collection of representative soil samples. The excavation subcontractor is directed by the project geologist/engineer to complete a test pit/trench at a designated location. The lateral extent and depth of the test pit/trench is dependent upon project objectives. Once excavated, the test pit/trench is logged and sampled, if required. Following this, the test pit/trench is backfilled with the excavated material or with clean fill.

1.3 Quality Assurance Planning Considerations

Project personnel should follow specific quality assurance guidelines for sampling as outlined in the site-specific Quality Assurance Project Plan (QAPP) and/or Sampling Plan. Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements typically suggest the collection of a sufficient quantity of field duplicate, field blank, and equipment blank samples.

1.4 Health and Safety Considerations

All utilities (electric, water, sewer, etc.) or property owners who may have equipment or transmission lines buried in the vicinity of proposed test pits should be notified. Many regions have organizations that represent all utilities for these notification purposes. Sufficient time should be allowed after notification (typically 3 working days) for the utilities to respond and mark locations of any equipment that may be buried on site. It should be noted, however, that these organizations may not be responsible for locating utilities on private property. This is often the responsibility of the property owner. The estimated location of utility installations, such as sewer, telephone, electric, water lines and other underground installations that may reasonably be expected to be encountered during excavation work, shall be verified by the site owner prior to opening an excavation. The subcontractors will be made aware of the potential of encountering underground utilities at each test pit location.

To avoid the hazards associated with the cave-in or collapse of an excavation or trench, AECOM employees will not enter an excavation or trench to collect the required samples. Samples will be collected remotely, using long-handled sampling tools, or directly from the bucket of the backhoe. If entry becomes necessary and the excavation is greater than 5 feet in depth, the contractor will be required to slope or shore the walls of the excavation. Specific requirements will depend on soil type and site constraints and will be addressed in the site-specific health and safety plan (HASP). All sloping or shoring must be conducted in compliance with OSHA's rules for trenching and excavation (29 CFR 1926.650-652.)

For safety reasons in case of sidewall collapse, all personnel and materials will be kept at least 2 feet from the edge of any open excavation. Open excavations can be viewed by the geologist from test pit endwalls which are more stable than test pit sidewalls.

If excavations are to be left open temporarily, the perimeter of the excavation must be marked with "Caution-Open Trench" tape. Other site-specific restrictions on leaving test pits open temporarily may be required by the property owner. Those requirements should be determined prior to startup of the excavation program.

Ambient air quality conditions should be periodically monitored both within and surrounding the excavation for potentially toxic and/or explosive atmospheric conditions. The project HASP should be reviewed for specific information regarding ambient air quality monitoring.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager will be responsible for ensuring that the project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the work in accordance with this SOP and the project plan.

2.2 Project Geologist/Engineer

It will be the responsibility of the geologist or engineer to determine the location, total depth and overall size of each test pit/trench. It will also be his or her responsibility to collect representative samples from the test pit/trench and to log the test pit/trench according to the procedures described in this SOP.

2.3 Subcontractor

It will be the responsibility of subcontractors to construct test pits/trenches according to AECOM project-specific requirements and in accordance with OSHA safety requirements for trench construction.

3.0 REQUIRED MATERIALS

- Stakes
- Fluorescent flagging tape/caution tape
- Sample kit (i.e., bottles/labels, custody records, cooler, ice, etc.)
- Measuring tape
- Compass (optional)
- Camera
- Sheet plastic
- Sampling equipment: spoons, trowels, scoops, shovels
- Field records: test pit log, test pit profile log
- Field logbook/pen
- Project plans (HASP, QAPP, Sampling Plan)
- Decontamination materials and solutions

4.0 METHOD

4.1 General Preparation

General locations for test pits or trenches should be marked with a stake and/or flagging tape prior to start of the excavation program. Final post-excavation locations should be documented by using topographic maps and/or other site plans. Final locations should also be measured from a fixed feature or surveyed if necessary.

Excavation equipment should be properly decontaminated prior to initial use, between test pit/trench excavations, and following completion of the last excavation. It should be noted that excavation equipment may need to be brushed clean or fully decontaminated at the completed test pit location if the potential exists for spreading contaminated soils by transport of the excavation equipment.

4.2 Excavation

Test pits/trenches will be excavated to the depth specified in the project-specific plan. Test pit completion depths should be indicated to the subcontractor by the project geologist or engineer. The test pits or trenches will be excavated in compliance with applicable safety regulations. Walls should initially be cut as near vertical as possible to facilitate stratigraphic mapping. Proper sidewall sloping will, however, be required for test pits that extend beyond 5 feet in depth if sampling or logging personnel require access to the open excavation.

As the test pit/trench is excavated, the excavated soils should be placed to one side of the excavation and no closer than 2 to 3 feet from the excavation's edge. Depending on the project requirements, sheet plastic may be required to cover the ground surface before placing excavation soils on the ground.

Excavation should proceed slowly and with caution. The project geologist/engineer should view the excavation (from the far end wall) after each removed bucket of soil for the presence of unusual features such as waste accumulations, free liquids (water or free product), and buried utilities. The excavation subcontractor should continue the excavation only after receiving approval to proceed from the project geologist/engineer.

4.3 Logging

A test pit log will be prepared in the field by the geologist or engineer. The test pit log, which is similar to a boring log, will include notations on soil types and depth of stratigraphic changes, depth to water table, identification of waste materials, and the depth/location of any environmental samples that were collected. The dimensions and orientation of each test pit/trench will also be recorded on the test pit log.

A supplemental sketch is often necessary to depict the physical orientation of the strata encountered. These observations should be recorded on the test pit profile log.
The test pit profile log allows for sketching a view of the test pit sidewall (i.e., a test pit cross section) and for listing of sample collection information.

The project geologist/engineer will measure the depth to the groundwater table in test pits, if encountered, only after sufficient time is allowed for stabilization of the groundwater table. If there is insufficient time to achieve stabilization, the depth to where groundwater is entering the test pit should be indicated on the logs.

If photographs are necessary, they can be taken at this time.

4.4 Sample Collection

Requirements for soil sampling will be determined by the project geologist/engineer in accordance with the project sampling plan.

Soil samples may be collected for several reasons including stratigraphic logging, field headspace organic vapor testing, and laboratory environmental testing. Various types of sampling equipment are commonly available for use in sample collection. SOP 7110 (Surface Soil Sampling) provides instruction in the use of scoops, trowels, shovels, and other types of soil sampling equipment. Guidance on decontamination of field equipment is provided in SOP 7600.

Soil samples may be collected from test pits/trenches from several locations: the test pit/trench sidewalls or base, the excavated soil pile, or directly from the backhoe bucket. Additional information regarding each sampling method are presented in the following subsections.

4.4.1 Test Pit/Trench Sidewall or Base Sampling

Test pit/trench sidewall or base sampling is generally the preferred method by regulatory agencies because it allows for in-situ sampling of soils. In-situ sampling limits the potential for sample contamination which can occur during the excavation procedures. This method, valid for any type of proposed analysis, is especially preferred for samples which will be analyzed for volatile organic compounds (VOC).

Sidewall or base sampling is considered to be somewhat more dangerous than sampling from the soil pile or backhoe bucket because it may require entry of sampling personnel into the excavation. A recommended option in place of entry into the excavation is to use long-handled sampling equipment. The use of long-handled sampling equipment allows for collection of samples without entry into the excavation and often from the excavation ends where it is generally considered safe. Long-handled sampling equipment can be fabricated using standard surface soil sampling equipment (trowels, scoops, etc.) attached to long wooden or aluminum extension handles with duct tape or clamps. When using duct tape, or any kind of tape, caution should be exercised during sampling not letting the sample come into contact with the tape or handle.

Regardless of whether entry into the excavation is required, sampling should be conducted in the following manner:

- Select the sampling location and “dress” the excavation surface by scraping to remove any loose surface soil or smearing residues.
- Replace the dressing tool with a clean sampling tool.
- Collect the soil sample with the sampling tool in accordance with the methods outlined within SOP 7110 (Surface Soil Sampling).
- Complete the test pit log and test pit profile log to provide description and location information for each sample collected.

4.4.2 Excavated Soil Pile Sampling

This method is considered favorable for soil logging and headspace VOC testing in the field. It is, however, generally considered unsuitable for collection of samples for laboratory analytical testing for the simple reason that it is difficult to determine the exact position in the test pit/trench from which the sample was obtained.

Sampling from the soil pile is recommended if single or composite soil samples are required for general soil quality testing or when larger quantities of soil are needed for testing. Soil pile sampling is accomplished following the same methods specified in SOP 7110.

4.4.3 Backhoe Bucket Sampling

Sampling from the backhoe bucket is an improvement on soil pile sampling in that the geologist or engineer is reasonably sure of the position where the soil was obtained. Backhoe bucket sampling is considered suitable for soil logging and headspace VOC testing; however, it is generally considered to be unsuitable for analytical testing. Sampling from the backhoe bucket may be considered suitable for analytical testing if, for instance, the base of the test pit is covered with water and use of standard sampling equipment has been unsuccessful in retrieving an unacceptable sample.

Backhoe bucket sampling is accomplished following the same methods specified in SOP 7110. If analytical testing is the objective, however, certain precautions must be taken. The bucket must be free of rust, grease, and paint. Some care is required to obtain a sample which has been minimally disturbed. For example, if a cohesive block of soil is present within the bucket, the soil sample should be retrieved from within the block of soil as much as possible. Only soil that has not been in contact with the backhoe bucket should be taken for analytical testing.

4.4.4 General Sampling Procedures

Representative samples shall be collected for laboratory analysis by the project geologist/engineer using the appropriate equipment.

Sample bottling, handling and transport shall be conducted in accordance with the requirements of the project specific QAPP.

Specific procedures pertaining to the handling and shipment of samples can be found in AECOM SOP 7510 (Packaging and Shipment of Samples).

4.5 Backfilling

Prior to backfilling, all collected information will be reviewed to ensure that all the appropriate and/or required logs, photographs, measurements and samples have been collected.

After review of the records, backfilling and compaction of test pit/trenches will be accomplished according to contract specifications. If excavation sidewalls have been undermined, the excavation may require temporary expansion to backfill properly.

All test pits/trenches will be backfilled to original grade unless otherwise specified.

It should be noted that project-specific requirements may include the use of clean backfill material. The requirements for clean backfill and the potential requirements for disposal of excavated soils should be defined within the project-specific plan.

5.0 QUALITY CONTROL

Quality control requirements for sample collection are dependent on project-specific sampling objectives. The QAPP will provide requirements for sample preservation and holding times, container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Test pit locations shall be referenced on the site map. Sample locations shall be referenced on a plan view/vertical section of each test pit/trench.

Photographs of specific geologic features may be required for documentation purposes. A scale or an item providing a size perspective shall be placed in each photograph. Frame number/picture location shall also be documented in the field log book.

The following records will be maintained:

- Test Pit Log (Figure 1) and/or Test Pit Profile Log (Figure 2)
- Sample collection records
- Field notebook
- Chain-of-custody forms
- Shipping receipts

All documentation will be placed in the project files and retained following completion of the project.

7.0 TRAINING/QUALIFICATIONS

Test pit/trench subsurface explorations require a moderate degree of training and experience as numerous situations may occur which will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several test pit/trench explorations before working on their own. Experienced excavation subcontractors are also of great assistance with problem resolution in the field. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

8.0 REFERENCES

United States Environmental Protection Agency. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM). USEPA, Region 4, Enforcement and Investigations Branch, Athens, GA. November 2001.

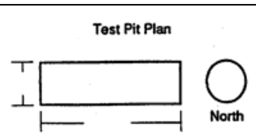
29 CFR Part 1926.650-652.

TEST PIT LOG

Sheet 9 of 1.

Project Number:	Date:	Test Pit:
Project Name:	Contractor:	Total Depth:
Location:		Ground Elevation:
Equipment Used:		Logged By:
Remarks:		

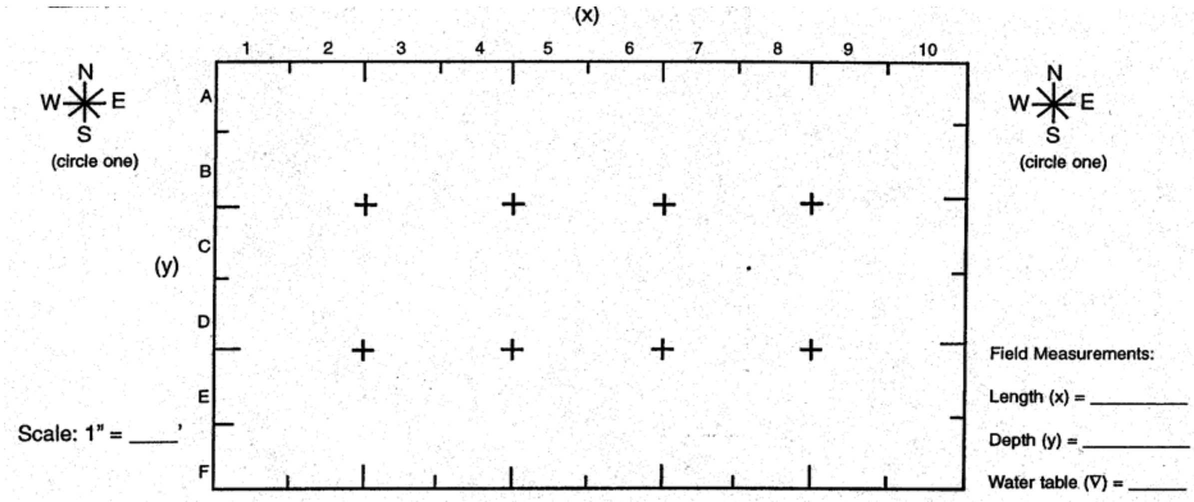
Elev. Feet	**Depth Feet**	**Sample**		**Soil & Rock Description and Comments**
		Type & No.	**Depth Range**	

Test Pit Plan	**Groundwater**		
 	**Date**	**Time (Hrs. after Completion)**	**Depth (Feet)**

TEST PIT PROFILE LOG

Project Number:	Test Pit No.:
Project Name:	Date:
Project Location:	Inspector:

Field Sketch:



Sample Summary:

Sample	Sample I.D.	Time	Depth(ft)	Hor. Loc.	Matrix	Misc. Information	PID	
B								
C								
D								
E								
F								
G								

SOP NUMBER: 7510

Packaging and Shipment of Environmental Samples

Date:	4th Qtr. 1999
Revision Number:	4
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of environmental samples. Two general categories of samples exist: environmental samples consisting of water and soil submitted for routine environmental testing, and waste material samples which include non-hazardous solid wastes and/or hazardous wastes as defined by 40 CFR Part 261 submitted for environmental testing or bench/pilot-scale treatability testing. Packaging and shipping procedures will differ for the two sample categories.

This SOP is applicable to packaging and shipment of environmental samples submitted for routine environmental testing. Environmental samples are not considered a hazardous waste by definition; therefore, more stringent Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require fairly stringent packaging and shipping measures to ensure sample integrity as well as safety for those individuals handling and transporting the samples.

This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service, therefore, the procedures are more stringent than may be necessary if a laboratory courier is used or if samples are transported directly to their destination by a sampling team member. Should the latter occur, the procedures may be modified to reflect a lesser degree of packaging requirements.

Respective state or federal agency (regional offices) protocols may require or recommend specific types of equipment for use in sample packaging or a specific method of shipment that may vary from the indicated procedures. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Sample packaging and shipment generally involves the placement of individual sample containers into a cooler or other similar shipping container and placement of packing materials and coolant in such a manner as to isolate the samples, maintain the required temperature, and to limit the potential for damage to sample containers when the cooler is transported.

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific work plan or Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will specify sample packaging and shipment requirements if variations to the indicated procedures are necessary on a particular project.

1.4 Health and Safety Considerations

Sampling personnel should be aware that packaging and shipment of samples involves potential physical hazards primarily associated with handling of occasional broken sample containers and lifting of heavy objects. Adequate health and safety measures must be taken to protect sampling personnel from these potential hazards. The project Health and Safety Plan (HASP) generally addresses physical and other potential hazards. This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed. In the absence of a HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 Sampling Technician

It is the responsibility of the sampling technician to be familiar with the procedures outlined within this SOP and with specific sampling, quality assurance, and health and safety requirements outlined within the project-specific plans. The sampling technician is responsible for proper packaging and shipment of environmental samples and for proper documentation of sampling activities for the duration of the sampling program.

2.2 Sampling Coordinator

Large sampling programs may require additional support personnel such as a sampling coordinator. The sampling coordinator is responsible for providing management support such as maintaining an orderly sampling process, providing instructions to sampling technicians regarding sampling locations, and fulfilling sample documentation requirements, thereby allowing sampling technicians to collect samples in an efficient manner.

2.3 Project Manager

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the activities in accordance with the project plan and this SOP. The project manager is also responsible for ensuring that proper arrangements have been made with the designated analytical laboratory. These arrangements include, but are not necessarily limited to, subcontractor agreements, analytical scheduling, and bottle/cooler orders. The project manager may delegate some of these responsibilities to other project staff.

3.0 REQUIRED MATERIALS

- Sample coolers
- Sample containers
- Shipping labels
- Chain-of-custody records, custody seals
- Bubble wrap
- Vermiculite (granular), or styrofoam pellets
- "Blue Ice" refreezable ice packs, or ice cubes
- Transparent tape, or rubber bands
- Fiber tape
- Duct tape
- Zipper-lock plastic bags

- Trash bags
- Health and Safety supplies
- Equipment decontamination materials
- Field project notebook/pen

4.0 METHOD

4.1 General Information

4.1.1 Regulatory Information

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when any of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;
- Samples are being transported to the collector from the laboratory after analysis;
- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

4.1.2 Sample Information:

The following information must accompany each shipment of samples on a chain-of-custody form (Figure 1) where each sample has an individual entry:

- Sample collector's name, mailing address and telephone number,
- Analytical laboratory's name, mailing address and telephone number,
- A unique identification of each sample,

- Sample description (matrix),
- Number and type of sample containers,
- Container size,
- Preservative,
- Type and method of analysis requested, and
- Date and time that the samples were collected and prepared for shipping,
- Special handling instructions, including notation of suspected high concentration samples.

4.1.3 Laboratory Notifications:

Prior to sample collection, the Project Manager, or designated alternative must notify the laboratory manager of the number, type and approximate collection and shipment dates for the samples. If the number, type or date of sample shipment changes due to program changes which may occur in the field, the Project Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for weekend delivery.

4.2 General Site Preparation

4.2.1 Small Projects

Small projects of one or two days duration may require packaging and shipment of samples using the field vehicle as the sample preparation area. If sample coolers will be sent via third party commercial carrier service, adequate sample packaging materials should be sent to the project location in advance of sampling or purchased from stores located near the site.

4.2.2 Large Projects

Multi-day or week sampling programs usually require rental of an office trailer or use of existing office/storage facilities for storage of equipment as well as for sample preparation. If possible, a designated area should be selected for storage of unused sample containers/coolers and another area for sample handling, packaging, and shipment. Handling of environmental samples should preferably be conducted in a clean area and away from unused sample containers to minimize the potential for cross contamination. Large quantities of packaging materials may require advance special ordering. Shipping forms/labels may be preprinted to facilitate shipping.

4.2.3 Cooler Inspection and Decontamination

Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for condition and cleanliness. Any coolers that have cracked interior or exterior linings/panels or hinges should be discarded as their insulating properties are now compromised. Any coolers missing one or both handles should also be discarded if replacement handles (i.e., knotted rope handles) can not be fashioned in the field. Replacement coolers may be purchased in the field if necessary.

The interior and exterior of each cooler should be inspected for cleanliness before using it. Excess strapping tape and old shipping labels should be removed. If the cooler interior exhibits visible contamination or odors it should be decontaminated in accordance with AECOM SOP-7600 (Decontamination of Equipment) prior to use. Drain plugs should be sealed on the inside with duct tape.

4.2.4 Other Considerations

VOC Samples - Sample containers used for VOC analysis may be grouped into a single cooler, with separate chain-of-custody record, to limit the number of trip blanks required for transportation and analysis. Individual VOC samples may also be placed into Zipper-lock bags to further protect the samples.

Contaminated Samples - Sample containers with presumed high contaminant concentrations should be isolated within their own cooler with each sample container placed into a Zipper-lock bag.

4.3 Sample Packaging Method

Sample packaging should be conducted in the following manner:

4.3.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed. A 2- to 3-inch thickness layer of vermiculite may be used as a substitute base material.

4.3.2 Insert a clean trash bag into the cooler to serve as a liner.

4.3.3 Check that each sample container is sealed, labelled legibly, and is externally clean. Re-label and/or wipe bottles clean if necessary. Clear tape should be placed over the labels to protect them. Wrap each sample bottle individually with bubble wrap secured with tape or rubber bands. Place bottles into the cooler in an upright single layer with approximately one inch of space between each bottle. Do not stack bottles or place them in the cooler lying on their side. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so that glass bottles are not placed side by side.

4.3.4 Insert cooler temperature blanks if required.

4.3.5 Place additional vermiculite, bubble wrap, and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler to a level which meets the approximate top of the sample containers. Packing material may require tamping by hand to reduce the potential for settling.

4.3.6 Place cubed ice or cold packs in heavy duty Zip-lock type plastic bags, close the bags, and distribute the packages in a layer over the top of the samples. Cubed ice should be double-bagged to prevent leakage. Loose ice should never be used. Cold packs should be used only if the samples are chilled before being placed in the cooler.

4.3.7 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

4.3.8 Obtain two pieces of chain of custody tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the chain-of-custody form. Sign and date the chain-of-custody tape.

4.3.9 Complete the chain-of-custody form. If shipping the samples involves use of a third party commercial carrier service, sign the chain-of-custody record thereby relinquishing custody of the samples. Shippers should not be asked to sign chain of custody records. If a laboratory courier is used, or if samples are transported to the laboratory, the receiving party should accept custody and sign the chain-of-custody records. Remove the last copy from the form and retain it with other field notes. Place the original (with remaining copies) in a Zipper-lock type plastic bag and tape the bag to the inside lid of the cooler or shipping container.

4.3.10 Close the top or lid of the cooler or shipping container.

4.3.11 Place the chain of custody tape at two different locations (i.e., one tape on each side) on the cooler or container lid and overlap with transparent packaging tape.

4.3.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler.

4.3.13 Repeat the above steps for each cooler or shipping container.

4.4 Sample Shipping Method

Packaged sample coolers should be shipped using one of the following options:

4.4.1 Hand Delivery

When a project member is transporting samples by automobile to the laboratory, the cooler should only be sealed with tape. In these cases, chain-of-custody will be maintained by the person transporting the sample and chain-of-custody tape need not be used. Chain-of-custody records should be relinquished upon delivery and a copy of the record retained in the project file.

4.4.2 Laboratory Courier

Laboratory couriers are usually employees of the analytical laboratory receiving the samples. As such, they will accept custody of the samples and must be asked to sign the chain-of-custody records. Chain-of-custody records do not need to be sealed in the cooler although it is recommended that the coolers be sealed with tape. All other packaging requirements generally apply unless otherwise specified in the QAPP.

If the laboratory courier is not authorized to accept custody of the samples, or if the requirements of the project plan preclude transfer to the laboratory courier, samples will be handled as described below in Section 4.4.3.

4.4.3 Third Party Courier

If overnight shipment is required, a third party package delivery service should be used. Transport the cooler to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler. Keep the receipt for package tracking purposes should a package become lost. Please note that each cooler also requires a shipping label which indicates point of origin and destination. This will aid in recovery of a lost cooler if a shipping form gets misplaced. Never leave coolers unattended while waiting for package pick-up. Airbills or waybills will be maintained as part of the custody documentation.

4.5 Sample Receipt

Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain-of-custody form. The laboratory will verify that the chain-of-custody tape has not been broken previously and that the tape number corresponds with the number on the chain-of-custody record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler and chain-of-custody. The analytical laboratory will then forward the back copy of the chain-of-custody record to the project manager to indicate that sample transmittal is complete.

5.0 QUALITY CONTROL

The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler. Completed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of a 40-ml vial or plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler.

6.0 DOCUMENTATION

Documentation supporting sample packaging and shipment generally consists of chain-of-custody records and shipping records. In addition, a description of sample packaging procedures will be written in the field project notebook. All documentation will be retained in the project files following project completion.

7.0 TRAINING/QUALIFICATIONS

Sample packaging and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is, however, recommended that initial attempts be supervised by more experienced personnel. Sampling technicians should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

Figure 1. Chain of Custody Form

0

CHAIN OF CUSTODY RECORD

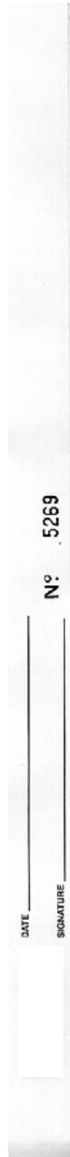
3DJH _____ RI _____

&OLHQW3URMHFW1DPH	3URMHFW/RFDWLRQ	$QDO\VLV5HTXHVWHG
3URMHFW1XPEHU	)LHOG/RJERRN1R	
6DPSOHU3ULQW1DPH$IILOLDWLRQ	&KDLQRI&XVWRG\7DSH1R	
6LJQDWXUH	6HQG5HVXOWV5HSRUWWR	

)LHOG6DPSOH1R ,GHQWLILFDWLRQ	'DWH	7LPH	*UDE	&RPS	6DPSOH&RQWDLQHU 6L]H0DWO	6DPSOH7\SH /LTXLG6ROLG$LU(WF	3UHVHUYDWLYH	)LHOG)LOWHUHG							/DE,'	5HPDUNV

5HOLQTXLVKHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	5HFHLYHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	$QDO\WLFDO/DERUDWRU\'HVWLQDWLRQ (165 :/D3RUWH$YH)RUW&ROOLQV&2
5HOLQTXLVKHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	5HFHLYHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	
5HOLQTXLVKHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	5HFHLYHGE\3ULQW1DPH 6LJQDWXUH	'DWH 7LPH	6HULDO1R

Figure 2. Chain of Custody Tape



SOP NUMBER: 7600

Decontamination of Field Equipment

Date:	4th Qtr. 1994
Revision Number:	4
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This SOP describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. The list of field equipment may include a variety of items used in the collection of soil and/or water samples, such as split-spoon samplers, trowels, scoops, spoons, bailers and pumps. Heavy equipment such as drill rigs and backhoes also require decontamination, usually in a specially constructed temporary decontamination area.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination. Decontamination protects field personnel from potential exposure to hazardous materials. Decontamination also protects the community by preventing transportation of contaminants from a site.

This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Occasionally, dedicated field equipment such as well construction materials (well screen and riser pipe) or disposable field equipment (bailers or other general sampling implements) may also require decontamination prior to use. The project-specific work plan should indicate the specific decontamination requirements for a particular project.

Respective state or federal agency (regional offices) regulations may require specific types of equipment or procedures for use in decontamination of field equipment. The project manager should review the applicable regulatory requirements, if any, prior to the start of the field investigation program.

1.2 General Principles

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam and/or high pressure water, or solvents. The decontamination method and agents are generally determined on a project-specific basis and must be stated in the Quality Assurance Project Plan (QAPP).

Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation-derived waste for later disposal. All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the investigation program.

1.3 Quality Assurance Planning Considerations

1.3.1 General Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific QAPP. The QAPP guidelines typically require collection of equipment blank samples in order to determine the effectiveness of the decontamination procedure.

The decontamination method, solvent, frequency, location on site and the method of containment and disposal of decontamination wash solids and solutions are dependent on site logistics, site-specific chemistry, and nature of the contaminated media to be studied and the objectives of the study. Each topic must be considered and addressed during development of a decontamination strategy and should be outlined in the Quality Assurance Project Plan (QAPP).

1.3.2 Solvent Selection

There are several factors which need to be considered when deciding upon a decontamination solvent. The solvent should not be an analyte of interest. The sampling equipment must be resistant to the solvent. The solvent must be evaporative or water soluble or preferably both. The applicable regulatory agency may have specific requirements regarding decontamination solvents. The QAPP should specify the type of solvent to be used for a particular project.

The analytical objectives of the study must also be considered when deciding upon a decontamination solvent. Pesticide-grade methanol is the solvent of choice for general organic analyses. It is relatively safe and effective. Hexane, acetone, and isopropanol are sometimes used as well. A 10% nitric acid in deionized water solution is the solvent of choice for general metals analyses. Nitric acid can be used only on Teflon, plastics and glass. If used on metal equipment, nitric acid will eventually corrode the metal and lead to the introduction of metals to the collected samples. Dilute hydrochloric acid is usually preferred over nitric acid when cleaning metal sampling equipment.

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities but close enough to the sampling area to maintain an efficient working environment. If heavy equipment such as drill rigs or backhoes are to be decontaminated, then a central decontamination station should be constructed with access to a power source and water supply.

1.4 Health and Safety Considerations

Decontamination procedures may involve chemical exposure hazards associated with the type of contaminants encountered or solvents employed and may involve physical hazards associated with decontamination equipment. When decontamination is performed on equipment which has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Sampling Technician

It is the responsibility of the sampling technician to be familiar with the decontamination procedures outlined within this SOP and with specific quality assurance, and health and safety requirements outlined within project-specific work plans (HASP, QAPP). The sampling technician is responsible for decontamination of field equipment and for proper documentation of decontamination activities. The sampling technician is also responsible for ensuring that decontamination procedures are followed by subcontractors when heavy equipment requires decontamination.

2.2 Field Project Manager

The field project manager is responsible for ensuring that the required decontamination procedures are followed at all times. The project manager is also responsible for ensuring that subcontractors construct and operate their decontamination facilities according to project specifications. The project manager is responsible for collection and control of IDW in accordance with project specifications.

3.0 REQUIRED MATERIALS

- Decontamination agents (per work plan requirements):
    - LIQUI-NOX, ALCONOX, or other phosphate-free biodegradable detergent,
    - Tap water,
    - Distilled/deionized water,
    - Nitric acid and/or hydrochloric acid,
    - Methanol and/or hexane, acetone, isopropanol.
- Health and Safety equipment
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon pails w/covers, plastic bags
- Cleaning containers: plastic buckets or tubs, galvanized steel pans, pump cleaning cylinder
- Cleaning brushes
- Pressure sprayers
- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Field project notebook/pen

4.0 METHODS

4.1 General Preparation

4.1.1 It should be assumed that all sampling equipment, even new items, are contaminated until the proper decontamination procedures have been performed on them or unless a certificate of analysis is available which demonstrates the items cleanliness.

Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears contaminated and/or has been stored for long periods of time. Unless customized procedures are stated in the QAPP for decontamination of equipment, the standard procedures specified in this SOP shall be followed.

4.1.2 Establish the decontamination station within an area that is convenient to the sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station, or a portable decontamination station should be established.

4.1.3 An investigation-derived waste (IDW) containment station should be established at this time also. The project-specific work plan should specify the requirements for IDW containment. In general, decontamination solutions are discarded as IDW between sampling locations. Solid waste is disposed of as it is generated.

4.2 Decontamination for Organic Analyses

4.2.1 This procedure applies to soil sampling and groundwater sampling equipment used in the collection of environmental samples submitted for organic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items. Submersible pump decontamination procedures are outlined in Section 4.4.

4.2.2 Decontamination is to be performed before sampling events and between sampling points.

4.2.3 After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water.

This initial step may be completed using a 5-gallon pail filled with tap water. Steam or a high-pressure water rinse may also be conducted to remove solids and/or other contamination.

4.2.4 Wash the equipment with a phosphate-free detergent and tap water solution. This solution should be kept in a 5-gallon pail with its own brush.

4.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

4.2.6 Rinse with methanol or other appropriate solvent using a squeeze bottle or pressure sprayer. Rinsate should be collected in a waste bucket.

4.2.7 Rerinse with deionized water to remove any residual solvent. Rinsate should be collected in the solvent waste bucket.

4.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in tin foil and/or seal it in a plastic bag if it will not be reused for a while.

4.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

4.3 Decontamination for Inorganic (Metals) Analyses

4.3.1 This procedure applies to soil sampling equipment used primarily in the collection of environmental samples submitted for inorganic constituents analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items.

4.3.2 For plastic and glass sampling equipment, follow the steps outlined in 4.2 above, however, use a 10% nitric acid solution (acid in water) in place of the solvent rinse in Section 4.2.6.

4.3.3 For metal sampling equipment, follow the steps outlined in 4.2 above, however, use a 10% hydrochloric acid solution (acid in water) in place of the solvent rinse in Section 4.2.6.

4.4 Decontamination of Submersible Pumps

4.4.1 This procedure will be used to decontaminate submersible pumps before and between ground-water sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure also applies to discharge tubing if it will be reused between sampling points.

4.4.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

4.4.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

4.4.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

4.4.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

4.4.6 Place the pump into another cylinder/bucket containing a 10% solution of solvent (methanol, or other designated solvent) in distilled/deionized water. Pump until the detergent solution is removed. Collect the rinsate and handle as IDW.

4.4.7 Place the pump into another cylinder/bucket containing distilled/deionized water. Pump a minimum of 3 to 5 pump system volumes (pump and tubing) of water through the system. Collect the rinsate and handle as IDW.

4.4.8 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

4.4.9 Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump, discharge line, and power cord thoroughly, shake all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used again right away, the pump itself should also be wrapped with aluminum foil before placing it into the bag.

4.5 Decontamination of Large Equipment

4.5.1 Consult the QAPP for instruction on the location of the decontamination station and the method of containment of the wash solutions. On large projects usually a temporary decontamination facility (decontamination pad) is required which may include a membrane-lined and bermed area large enough to drive heavy equipment (drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump with pump is necessary to collect and contain rinsate. A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

4.5.2 Upon arrival and prior to leaving a sampling site, all heavy equipment such as drill rigs, trucks, and backhoes should be thoroughly cleaned and then the parts of the equipment which come in contact or in close proximity to sampling activity should be decontaminated. This can be accomplished in two ways, steam cleaning or high pressure water wash and manual scrubbing. Following this initial cleaning, only those parts of the equipment which come in close proximity to the sampling activities (i.e., auger stems, rods, backhoe bucket) must be decontaminated in between sampling events.

Occasionally, well construction materials such as well screen and riser pipe may require decontamination before the well materials are used. These materials may be washed in the decontamination pad, preferably on a raised surface above the pad (i.e., on sawhorses), with clean plastic draped over the work surfaces. Well materials usually do not require a multistep cleaning process as they generally arrive clean from the manufacturer. Usually, a thorough steam-cleaning of the interior/exterior of the well materials will be sufficient. The QAPP should provide specific guidance regarding decontamination of well materials.

5.0 QUALITY CONTROL

5.1 Field Blank Sample Collection

General guidelines for quality control check of field equipment decontamination usually require the collection of one field blank from the decontaminated equipment per day. The QAPP should specify the type and frequency of collection of each type of quality assurance sample.

Field blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Field blanks should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample. Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

6.0 DOCUMENTATION

Specific information regarding decontamination procedures should be documented in the project-specific field notebook. Documentation within the notebook should thoroughly describe the construction of each decontamination facility and the decontamination steps implemented in order to show compliance with the project work plan. Decontamination events should be logged when they occur with the following information documented:

- Date, time and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents
- Noteable circumstances
- Identification of field blanks and decontamination rinsates
- Method of blank and rinsate collection
- Date, time and location of blank and rinsate collection
- Disposition of IDW

Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

7.0 TRAINING/QUALIFICATIONS

All sampling technicians performing decontamination must be properly trained in the decontamination procedures employed, the project data quality objectives, health and safety procedures and the project QA procedures. Specific training or orientation will be provided for each project to ensure that personnel understand the special circumstances and requirements of that project. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

8.0 REFERENCES

Not applicable.

SOP NUMBER: 7220

Monitoring Well Construction and Installation

Date:	3rd Qtr., 1995
Revision Number:	4
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This SOP provides guidance for installing groundwater monitoring wells. Monitoring wells are installed to monitor the depth to groundwater, to measure aquifer properties, and to obtain samples of groundwater for chemical analysis.

This SOP is applicable to installation of single monitoring wells within a borehole. The construction and installation of nested, multilevel or other special well designs is not covered within this SOP as these type of wells are not frequently constructed. This SOP applies to both overburden and bedrock monitoring wells.

Some states and EPA Regions have promulgated comprehensive guidelines for monitoring well construction and for subsurface investigation procedures. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Monitoring well construction and installation generally involves drilling a borehole using conventional drilling equipment, installing commercially available well construction and filter/sealing materials, and development of the well prior to sampling. This SOP covers well construction and installation methods only. Borehole drilling and well development methods are covered under SOP-7115 (Subsurface Soil Sampling) and SOP-7221 (Monitoring Well Development), respectively.

1.3 Quality Assurance Planning Considerations

Field personnel should follow specific quality assurance guidelines as outlined in the site-specific QAPP.

The following aspects of monitoring well design and installation procedures depend on project-specific objectives which should be addressed in the QAPP and in the project work plan:

- Borehole drilling method and diameter,
- Type of construction materials for well screen, riser, filter pack and seals,
- Diameter of well materials,
- Length of well screen,
- Location, thickness, and composition of annular seals, and
- Well completion and surface protection requirements.

1.4 Health and Safety Considerations

Monitoring well installation may involve chemical hazards associated with materials in the soil or groundwater being investigated; and always involves physical hazards associated with drilling equipment and well construction methods. When wells are to be installed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan (HASP) must be prepared and approved by the Health and Safety Officer before field work commences. This plan must be distributed to all field personnel and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Drilling Subcontractor

It is the responsibility of the drilling subcontractor to provide the necessary equipment for well construction and installation. Well construction materials should be consistent with project requirements.

2.2 Surveying Subcontractor

It is the responsibility of the surveying subcontractor to provide one or more of the following well measurements as specified in the project work plan: ground surface elevation, horizontal well coordinates, top of well casing elevation (i.e., top-of-casing, or measuring point elevation), and/or top of protective casing elevation.

2.3 Project Geologist/Engineer

It is the responsibility of the Project Geologist/Engineer to directly oversee the construction and installation of the monitoring well by the drilling subcontractor to ensure that the well-installation specifications defined in the project work plan are adhered to, and that all pertinent data are recorded on the appropriate forms.

2.4 Project Manager

It is the responsibility of the Project Manager to ensure that each project involving monitoring well installation is properly planned and executed.

3.0 REQUIRED MATERIAL

3.1 Well Construction Materials

Well construction materials are usually provided by the drilling subcontractor and most often consist of commercially available flush-threaded well screen and riser pipe constructed of PVC or stainless steel with a minimum 2-inch inside diameter. The length of the screen and the size of the screen slots should be specified in the project work plan.

3.2 Well Completion Materials

Well completion materials include silica sand, bentonite, cement, protective casings and locks. Completion materials are generally provided by the drilling subcontractor.

3.3 Other required materials include the following:

- Potable water supply
- Fiberglass or steel measuring tape
- Water level indicator
- Well construction diagrams (Figure 1)
- Waterproof marker or paint (to label wells)
- Health and Safety supplies

- Equipment decontamination materials

- Field project notebook/pen

4.0 METHOD

4.1 General Preparation

4.1.1 Borehole Preparation

Standard drilling methods should be used to achieve the desired drilling/well installation depths specified in the project work plan. Soil sampling, if conducted, should be conducted in accordance with ENSR SOP-7115 (Subsurface Soil Sampling).

The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals. Bedrock wells may require reaming after coring in order to provide a large enough borehole diameter for well installation.

Rotary drilling methods requiring bentonite-based drilling fluids, if selected, should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.

If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.

4.1.2 Well Material Decontamination

Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor in accordance with ENSR SOP-7600 (Decontamination of Equipment).

4.2 Well Construction Procedure

4.2.1 Depth Measurement

Once the target drilling depth has been reached, the drilling subcontractor will measure the total open depth of the borehole with a weighted, calibrated tape measure. Adjustments of borehole depth can be made at this time by drilling further or installing a small amount of sand filter material to achieve the desired depth. If drilling fluids were used during the drilling process, the borehole should be flushed at this time using potable water. The water table depth may also be checked with a water level indicator if this measurement cannot be obtained with the calibrated tape.

4.2.2 Centralizers

In order to install a well which is centered within the borehole, it is recommended that centralizers be used. Centralizers are especially helpful for deep well installations where it may be difficult to position the well by hand. Centralizers may not be necessary on shallow water table well installations where the well completion depth is within 25 feet of the ground surface.

4.2.3 Well Construction

The well screen and riser pipe generally are assembled by hand as they are lowered into the borehole. Before the well screen is inserted into the borehole, the full length of the slotted portion of the well screen as well as the unslotted portion of the bottom of the screen should be measured with the measuring tape. These measurements should be recorded on the well construction diagram.

After the above measurement has been taken, the drilling subcontractor may begin assembling the well. As the assembled well is lowered, care should be taken to ensure that it is centered in the hole if centralizers are not used. The well should be temporarily capped before filter sand and other annular materials are installed.

4.2.4 Filter Sand Installation

The drilling subcontractor should fill the annular space surrounding the screened section of the monitoring well to at least 1 foot above the top of the screen with an appropriately graded, clean sand or fine gravel. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. If coarse filter materials are used, an additional 1-foot thick layer of fine sand should be placed immediately above the filter pack to prevent the infiltration of sealing components (bentonite or grout) into the filter pack. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. Depending upon depth, some time may be required for these materials to settle. If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deep water table wells and for wells which are screened some distance beneath the water table.

4.2.5 Bentonite Seal Installation

A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed by the drilling subcontractor immediately above the well screen filter pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well casing. Bentonite is used because it swells significantly upon contact with water. Pellets generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. As an option, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to inject the seal to the desired depth.

4.2.6 Annular Grout Seal Installation

This grout seal should consist of a bentonite/cement mix with a ratio of bentonite to cement of between 1:5 and 1:20. The grout ratio should be chosen based on site conditions with a higher percentage of bentonite generally used for formations with higher porosity. A mud balance should be used if a specific mud density is required at a particular site. Grout slurry should be pumped into the annular space using a side-discharging tremie pipe located about 2 feet above the sand pack. Side discharge will help preserve the integrity of the sand pack.

In situations where the monitoring well screen straddles the water table, the seal will be in the unsaturated zone and pure bentonites (pellets or powder) will not work effectively as seals without hydration. Dry bentonite may be used if sufficient time to hydrate the seal is allowed. Seal hydration requires the periodic addition of clean water. Optionally, seals in this situation may be a cement/bentonite mixture containing up to 10 percent bentonite by weight. This type of mixture shall be tremied to the desired depth in the borehole.

The borehole annulus will be grouted with seal materials to within 3 feet of the ground surface. Drill cuttings, even those known not to be contaminated, will not be used as backfill material.

4.2.7 Well Completion

The drilling subcontractor will cut the top of the well to the desired height and install a vented (if possible), locking cap. The upper portion of the well casing can optionally be drilled to allow venting. Well casings are usually cut to be a certain height above ground surface (typically 2.5 to 3 feet) or are cut to be flush with the ground surface.

4.2.8 Protective Casing/Concrete Pad Installation

The drilling subcontractor will install a steel guard pipe on the well as a protective casing. The borehole around the guard pipe will be dug out to an approximate 2 to 3-foot radius to a minimum depth of 1 foot at the center and 6 inches at the edges. After installing the protective casing, the excavation will be filled with a concrete/sand mix. The surface of the concrete pad will be sloped so that drainage occurs away from the well. Flush-mount protective casings may not require an extensive concrete pad and should be completed such that they are slightly mounded above the surrounding surface to prevent surface water from running over or ponding on top of the casing. It should be noted, however, that in areas subject to snowfall, flush-mount casings may have to be installed so that they are entirely flush with the ground surface as they may be damaged by snow plows.

Above-ground protective casings should also be vented or should have non-air tight caps. Road box installations should not be vented. Installation of additional guard pipes may be necessary around above-ground well completions in traffic areas. Protective casings should be lockable to prevent unauthorized access.

4.2.9 Well Numbering

The project geologist/engineer will number each well casing with an indelible marker or paint to identify the well. This is particularly important with nested or paired wells to distinguish between shallow and deep wells. The well should be labeled on both the outside of the protective casing and inside beneath the protective casing lid.

4.2.10 Measuring Point Identification

The project geologist/engineer will mark the measuring point from which water level measurements will be made at a specific location along the upper edge of the well casing. PVC wells can easily be notched with a pocket knife or saw. Stainless steel wells (or PVC wells) can be marked with a waterproof marker on the outside of the well casing with an arrow pointing to the measuring point location. The measuring point is the point which will require surveying during the well elevation survey task.

4.2.11 Well Measurements

Upon completion, the following well measurements should be taken by the project geologist/engineer and recorded on the well construction diagram (Figure 1):

- Depth to static water level if water level has stabilized,
- Total length of well measured from top-of-well casing,
- Height of well casing above ground surface,
- Height of protective casing above ground surface,
- Depth of bottom of protective casing below ground surface (may be estimated).

Well screen filter pack, bentonite seal and annular seal thicknesses and depths should also be recorded on the well construction diagram.

4.2.12 Disposal of Drilling Wastes

Drill cuttings and other investigation-derived wastes such as drilling mud or well development/purge water must be properly contained and disposed of. Site-specific requirements for collection and removal of these waste materials should be outlined within the project work plan. Containment of these materials should be performed by the drilling subcontractor.

4.2.13 Well Development

At some point after installation of a well and prior to use of the well for water-level measurements or collection of water quality samples, development of the well shall be undertaken in accordance with ENSR SOP-7221 (Monitoring Well Development). Well development may be performed by the drilling subcontractor if contracted to do so, or by the project geologist/engineer or other project staff.

4.2.14 Well Elevation Survey

At the completion of the well installation program, all monitoring wells are usually surveyed to provide, at a minimum, the top-of-casing measuring point elevation for water level monitoring purposes. Other surveyed points which may be required by the project work plan include: ground surface elevation, top of protective casing elevation, and well coordinate position. Well elevation surveys are usually conducted by a surveying subcontractor.

5.0 QUALITY CONTROL

Certain quality control measures should be taken to ensure proper well completion.

5.1 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, if necessary, before any well construction materials are placed.

5.2 Water level and non-aqueous phase liquid (NAPL) presence will be checked during well installation to ensure that the positions of well screen, sand pack, and seal, relative to water level, conform to project requirements.

5.3 The depth to the top of each layer of packing (i.e., sand, bentonite, grout, etc.) will be verified and adjusted if necessary to conform to project requirements before the next layer is placed.

5.4 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids may be required for analysis of chemical constituents of interest at the site.

6.0 DOCUMENTATION

All well construction data will be recorded on the Monitoring Well Construction Detail form (Figure 1). All wells will be referenced onto the appropriate site map. A field notebook and/or boring log will be used as additional means of recording data. In no case will the notebook or boring log take the place of the well construction diagram.

7.0 TRAINING/QUALIFICATIONS

Well construction and installation requires a moderate degree of training and experience as numerous drilling situations may occur which will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several well installations before working on their own. Experienced drillers are also of great assistance with problem resolution in the field. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

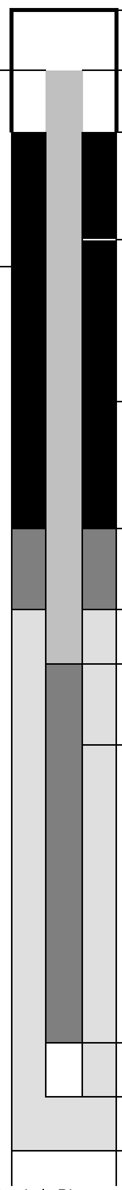
8.0 REFERENCES

1. Standard References for Monitoring Wells, Massachusetts Department of Environmental Protection, WSC-310-91, 1991.

Figure 1 Monitoring Well Construction Detail

	Client:	WELL ID:
	Project Number:	
	Site Location:	*Date installed:*
	Well Location: *Coords:*	*Inspector:*
	Method:	*Contractor:*

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation(feet) Datum ______
Top of Steel Guard Pipe	______	______
Top of Riser Pipe	______	______
Ground Surface (G.S.)	0.0	______
Top of Bentonite	______	______
Top of Sand	______	______
Top of Screen	______	______
▼ Stabilized Water Level	______	______
Bottom of Screen	______	______
Bottom of Tail Pipe:	______	______
Bottom of Borehole	______	______

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

______ % Cement

______ % Bentonite

______ % Native Materials

Riser Pipe:
- Length ______
- Inside Diameter (ID) ______
- Type of Material ______

Bottom of Steel Guard Pipe

Bentonite Seal Thickness ______

Screen:
- Length ______
- Inside Diameter (ID) ______
- Slot Size ______
- Type of Material ______

Type/Size of sand ______
Sand Pack Thickness ______

Bottom of Tail Pipe:
- Length ______

Borehole Diameter ______

Approved:

______ Signature ______ Date

Describe Measuring Point:

______

APPENDIX: DEFINITIONS

Annulus: The measured width between the borehole wall and the outside of the well screen or riser pipe.

Bentonite Seal: A granular, chip, or pellet-size bentonite material that is often used to provide an annular seal above the well screen filter pack. This seal is typically installed dry followed by in-place hydration with or without the addition of water. Hydrated bentonite is sometimes used as a grout seal.

Bottom Cap/Plug: Threaded or slip-on cap placed at the bottom of the well prior to installation. Often serves as a sump for accumulation of silt which settles within the well. The measured length from the lowermost well screen slot to the bottom of the bottom cap is known as the sump or tail pipe portion of the well.

Centralizers: Stainless steel expansion clamps which, when fitted to well screens or riser pipe, expand to contact the borehole walls positioning the well centrally within the open borehole. Centralizers assist with even positioning and distribution of filter pack and sealant materials and assist with maintaining well plumbness.

Expansion Cap/Well Cap: Cap used to cover the opening at the top of the well riser pipe. Expansion caps are equipped with a rubber gasket and threaded wing nut which, when turned, provides a watertight seal. Expansion caps may also be locked, and generally are recommended for use with flush-constructed wells where road box protective casings are also used. Other well caps may include slip-on or threaded caps made of the same material as the well casing.

Filter Pack: A well-graded, clean sand or gravel placed around the well screen to act as a filter in preventing the entry of very fine soil particles into the well.

Grout Seal: A cement/bentonite mixture used to seal a borehole that has been drilled to a depth greater than the final well installation depth or to seal the remaining borehole annulus once the well has been installed. Occasionally, pure cement or pure bentonite is used as a grout seal.

Measuring Point: A selected point at the top of the well casing (riser pipe) used for obtaining periodic water-level measurements. The measuring point should consist of either a notch or indelibly marked point on the upper surface of the casing. Typically, the highest point on the casing (if not level) is used as the measuring point. The measuring point is also the point that is surveyed when well elevation data is obtained.

Protective Casing: A locking metal casing, placed around that portion of the well riser pipe that extends above the ground surface. The protective casing is generally cemented in place when the concrete pad is constructed around the well.

Riser Pipe: The section of unperforated well casing material used to connect the well screen with the ground surface. Frequently, it is made of the same material and has the same diameter as the well screen. Riser pipe is typically available pre-cleaned and pre-threaded for immediate use.

Road Box: A protective casing that is flush-mounted with the ground around a well installation. Road boxes are used in areas where the monitoring well cannot extend above the ground surface for traffic or security reasons. Road boxes usually require a special key to open.

Tremie Pipe: A small diameter pipe which fits in the open borehole annulus and is used to inject filter sands or hydrated seal materials under pressure.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen is purchased pre-slotted, pre-cleaned, and pre-threaded for immediate use.

Vent Hole: Small diameter hole drilled in the upper portion of the well riser pipe which provides atmospheric venting of the well. Allows for constant equilibration of the water level with changing atmospheric conditions. In flood-prone areas, or with flush-mount wells, vent holes should not be used.

SOP NUMBER: 7221

Monitoring Well Development

Date:	4th Qtr., 1994
Revision Number:	2
Author:	Charles Martin
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This SOP describes the methods used for developing newly installed monitoring wells and/or existing wells which may require redevelopment/rehabilitation. This SOP is applicable to monitoring wells and/or small diameter recovery wells and piezometers.

Monitoring well development and/or redevelopment is necessary for several reasons:

- To improve/restore hydraulic conductivity of the surrounding formations as they have likely been disturbed during the drilling process, or may have become partially plugged with silt,

- To remove drilling fluids (water, mud), when used, from the borehole and surrounding formations, and

- To remove residual fines from well filter materials and reduce turbidity of groundwater, therefore, reducing the chance of chemical alteration of groundwater samples caused by suspended sediments.

Respective state or federal agency (regional offices) regulations may require specific types of equipment for use or variations in the indicated method of well development. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Well development generally involves withdrawal of an un-specified volume of water from a well using a pump, surge block or other suitable method such that, when completed effectively, the well is in good or restored hydraulic connection with the surrounding water bearing unit and is suitable for obtaining representative groundwater samples or for other testing purposes.

1.3 Quality Assurance Planning Considerations

Field project personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP) and/or Sampling Plan. The plan should indicate the preferred method of well development at a particular site based on project objectives, aquifer conditions, and agency requirements. Specific well performance criteria such as low turbidity values to be achieved following well development should also be specified as well as any requirements for collection/containerization and disposal of well development water.

1.4 Health and Safety Considerations

Monitoring well development may involve chemical hazards associated with materials in the soil or aquifer being characterized and may involve physical hazards associated with use of well development equipment. When wells are to be installed and developed on hazardous waste investigation sites, a Health and Safety Plan must be prepared and approved by the Health and Safety Officer before field work commences. This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all field project personnel, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Project Geologist/Engineer

Development or oversight of development of new monitoring wells is the responsibility of the project geologist/engineer involved in the original installation of the well. Records of well development methods and results will be retained in the project file.

2.2 Project Manager

The project manager is responsible for ensuring that the appropriate method of well development has been chosen which best meets project objectives, site hydrogeologic conditions, and/or relevant regulatory requirements.

3.0 REQUIRED MATERIALS

Well development can be performed using a variety of methods and equipment. The specific method chosen for development of any given well is governed by the purpose of the well, well diameter and materials, depth, accessibility, geologic conditions, static water level in the well, and type of contaminants present, if any.

The following list of equipment, each with their own particular application, may be used to develop and/or purge monitoring wells.

3.1 Bailer Purging

A bailer is used to purge silt-laden water from wells after using other devices such as a surge block. In some situations, the bailer can be used to develop a well by bailing and surging, often accompanied with pumping. A bailer should be used for purging in situations where the depth to static water is greater than 25 feet and/or where insufficient hydraulic head is available for use of other development methods.

3.2 Surge Block Development

Surge blocks are commercially available for use with Waterra™-type pumping systems or may be manufactured using a rubber or teflon "plunger" attached to a rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks if requested. A recommended design is shown in Figure 1.

3.3 Pump Development

A pump is often necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone can be used to develop the well and remove the fines by overpumping. Since the purpose of well development is to remove suspended solids from a well and surrounding filter pack, the pump must be capable of moving some solids without damage. The preferred pump is a submersible pump which can be used in both shallow and deep ground water situations. A centrifugal pump may be used in shallow wells but will work only where the depth to static ground water is less than approximately 25 feet. Pumping may not be successful in low-yielding aquifer materials or in wells with insufficient hydraulic head.

3.4 Compressed Gas Development

Compressed gas, generally nitrogen from a tank or compressed air through a compressor, can be used to both surge and develop a monitoring well. The method works by injection of compressed gas at the bottom of the water column, driving sediment-laden water to the surface. Compressed gas can also be used for "jetting" - a process by which the gas is directed at the slots in the well screen to cause turbulence (thereby disturbing fine materials in the adjacent filter pack). Compressed gas is not limited by any depth range.

Since the compressed gas will be used to "lift" water from the monitoring well, provisions must be made for controlling the discharge from contaminated wells. This is generally accomplished by attaching a "tee" discharge to the top of the casing and providing drums to contain the discharged water. Gas-lifting should never be done in contaminated wells without providing a means to control discharge.

3.5 Other Required Materials:

- Well development records (Figure 2)
- Health and Safety equipment
- Equipment decontamination materials
- Water quality instrumentation: nephelometer, pH, temperature, specific conductance meters, as required
- Field project notebook/pen

4.0 METHOD

4.1 General Preparation

4.1.1 Well Records Review: Well completion diagrams should be reviewed to determine well construction characteristics. Formation characteristics should also be determined from review of available boring logs.

4.1.2 Site Preparation: Well development, similar to groundwater sampling, should be conducted in as clean an environment as possible. This usually requires, at a minimum, placing sheet plastic on the ground to provide a clean working area for development equipment.

4.1.3 IDW Containment: Provisions should be in place for collection and management of investigation-derived wastes (IDW), specifically well development water and miscellaneous expendable materials generated during the development process. The collection of IDW in drums or tanks may be required depending on project-specific requirements. The QAPP should specify the requirements for IDW containment.

4.1.4 Water Level/Well Depth Measurement: The water level and well depth should be measured with a water level indicator and written on the well development record. This information is used to calculate the volume of standing water (i.e., the well volume) within the well.

4.1.5 Equipment Decontamination: All down-well equipment should be decontaminated prior to use in accordance with ENSR SOP-7600 (Decontamination of Equipment).

4.1.6 Removal of Drilling Fluids: Drilling fluids such as mud or water, if used during the drilling and well installation process, should be removed during the well development procedure. It is recommended that a minimum of 1.5 times the volume of added fluid be removed from the well during development. Drilling muds should initially have been flushed from the drilling casing during the well installation procedure with water added during the flushing process. If the quantity of added fluid is not known or could not be reasonably estimated, removal of a minimum of 10 well volumes of water is recommended during the development procedure.

4.2 Development Procedures

4.2.1 Development Method Selection

The construction details of each well shall be used to define the most suitable method of well development. Some consideration should be given to the potential degree of contamination in each well as this will impact IDW containment requirements.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and level of contamination, and characteristics of the geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

4.2.2 General Water Quality Measurements

Measure and record water temperature, pH, specific conductance, and turbidity periodically during development using the available water quality instruments. These measurements will aid in determining whether well development is proceeding efficiently, will assist in identifying when well development is complete, will determine whether the development process is effective or not with any given well and, potentially, may identify well construction irregularities (i.e., grout in well, poor well screen slot-size selection). Water quality parameters should be checked a minimum of 3 to 5 times during the development process.

4.2.3 Bailer Procedure

- As stated previously, bailers shall preferably not be used for well development but may be used in combination with a surge block to remove silt-laden water from the well.

- When using a bailer to purge well water; select the appropriate bailer, then tie a length of bailer cord onto the end of it.

- Lower the bailer into the screened interval of the monitoring well. Silt, if present, will generally accumulate within the lower portions of the well screen.

- The bailer may be raised and lowered repeatedly in the screened interval to further simulate the action of a surge block and pull silt through the well screen.

- Remove the bailer from the well and empty it into the appropriate storage container.

- Continue surging/bailing the well until sediment-free water is obtained. If moderate to heavy siltation is still present, the surge block procedure should be repeated and followed again with bailing.

- Check water quality parameters periodically.

4.2.4 Surge Block Procedure

- A surge block effectively develops most monitoring wells. This device first forces water within the well through the well screen and out into the formation, and then pulls water back through the screen into the well along with fine soil particles. Surge blocks may be manufactured to meet the design criteria shown in the example (Figure 1) or may be purchased as an adaptor to fit commercially available well purging systems such as the Waterra system.

- Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of approximately 3 feet, will allow material which is blocking the screen to separate and become suspended.

- After 5 to 10 plunger strokes, remove the surge block and purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. Discharge the purged water into the appropriate storage container.

- Repeat the process. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time. Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material.

- Check water quality parameters periodically.

4.2.5 Pump Procedure

- Well development using only a pump is most effective in monitoring wells that will yield water continuously. Theoretically, pumping will increase the hydraulic gradient and velocity of groundwater near the well by drawing the water level down. The increased velocity will move residual fine soil particles into the well and clear the well screen of this material. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

- When using a submersible pump or surface pump, set the intake of the pump or intake line in the center of the screened interval of the monitoring well.

- Pump a minimum of three well volumes of water from the well and raise and lower the pump line through the screened interval to remove any silt/laden water.

- Continue pumping water from the well until sediment-free water is obtained. This method may be combined with the manual surge block method if well yield is not rapid enough to extract silt from the surrounding formations.

- Check water quality parameters periodically.

4.2.6 Compressed Gas Procedure

- Although the equipment used to develop a well using this method is more difficult to obtain and use, well development using compressed gas is considered to be a very effective method. This method is also not limited by well depth, well diameter, or depth to static water. Caution must be exercised, however, in highly permeable formations not to inject gas into the formation. Drilling subcontractors will often provide the necessary materials as well as perform this method , if requested. When using a compressor, an oil-less compressor should be used, or an oil trap/filter should be placed on the air discharge line which enters the well.

- Lower the gas line into the well, setting it near the bottom of the screened interval. Install the discharge control equipment (i.e., tee fitting) at the well head.

- Set the gas flow rate to allow continuous discharge of water from the well.

- At intervals during gas-lifting, especially when the discharge begins to contain less suspended material , shut off the air flow and allow the water in the well to backflush through the screened interval to disturb any bridging that may have occurred. Re-establish the gas flow when the water level in the well has returned to the pre-development level.

- Continue gas-lifting and/or jetting until the discharged water is free from suspended material.

- Check water quality parameters periodically.

5.0 QUALITY CONTROL

A well has been successfully developed when one or more of the following criteria are met:

- The sediment load in the well has been eliminated or greatly reduced. Regulatory requirements may be in place which state that water turbidity values ranging from 5 to 50 NTU must be achieved at the end of the development procedure. Use of a nephelometer is required during the well development procedure to measure water turbidity if meeting a specific turbidity value is required by the regulations. Attaining low turbidity values in fine-grained formations may be difficult to achieve.

- Permeability tests conducted in accordance with ENSR SOP-7720 (Hydraulic Conductivity Testing) yield repeatable hydraulic conductivity values.

6.0 DOCUMENTATION

The Monitoring Well Development Record (Figure 2) will be completed by the geologist or hydrogeologist conducting the development. In addition, a field project notebook should be maintained detailing any problems or unusual conditions which may have occurred during the development process.

7.0 TRAINING/QUALIFICATIONS

Well development procedures vary in complexity. It is recommended that initial development attempts be supervised by more experienced personnel. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

8.0 REFERENCES

Standard References for Monitoring Wells, Massachusetts Department of Environmental Protection, WSC-310-91, 1991.

APPENDIX: DEFINITIONS

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: a characteristic property of aquifer materials which describes the permeability of the material with respect to flow of water.

Hydraulic Connection: A properly installed and developed monitoring well should have good hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer into the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Static Water Level: The water level in a well that represents an equilibrium or stabilized condition, usually with respect to atmospheric conditions in the case of monitoring wells.

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing standing water from a well to allow surrounding formation water to enter the well.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. The perforated, or slotted, portion of a well is also known as the screened interval.

Figure 1
Recommended Surge Block Design

SURGE BLOCK DESIGN
(Not to Scale)

Steel washers should be 1/2" to 3/4" smaller in diameter than the well ID. Gasket can be rubber or leather and should be the same diameter or 1/8" smaller than the well ID to compensate for swelling of the leather/ Rod can be steel, fiberglass, or plastic but must be strong and lightweight.

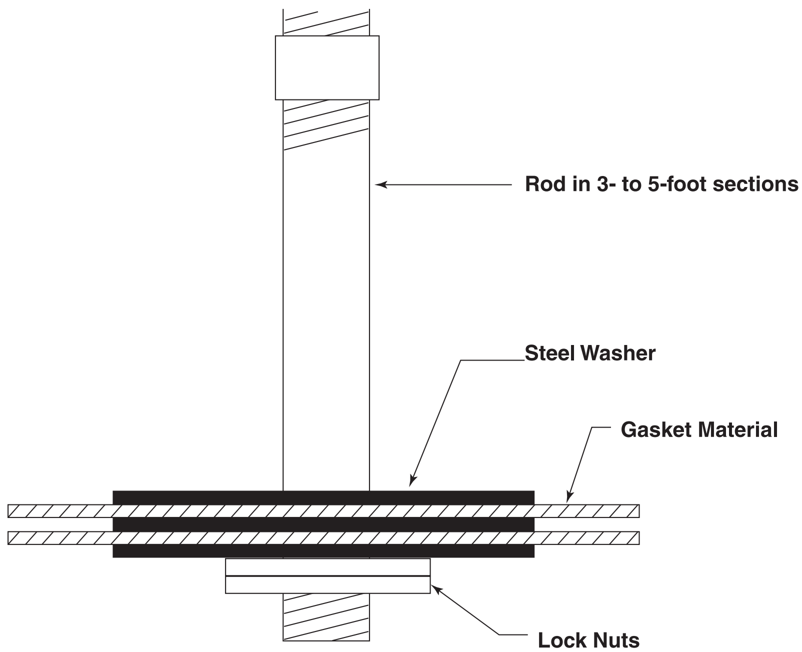


Figure 2
Well Development Record

MONITORING WELL DEVELOPMENT RECORD

DATE: ______________________ WELL I.D.: ______________________

PROJECT NAME: ______________________ LOCATION: ______________________

PROJECT NUMBER: ______________________ DEVELOPER: ______________________

☐ ORIGINAL DEVELOPMENT ☐ REDEVELOPMENT ORIGINAL DEVELOPMENT DATE: ______________________

WELL DATA	
Well Diameter: ______	Geology at Screened Interval:
Total Well Depth: ______	Likely Contaminants:
Depth to Top of Screen: ______	Purge Water & Sediment Disposal Method:
Depth to Bottom of Screen: ______	
Depth to Static Water Level: ______	

DEVELOPMENT METHOD	PURGE METHOD	PERMEABILITY TEST RESULTS

ACCEPTANCE CRITERIA

Signature: ______________________ Date: ____________

Aquifer Tests

1. Purpose

The purpose of this standard operating procedure is to establish standard methods by which United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command, Pacific (NAVFAC Pacific) personnel should conduct aquifer tests.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by both the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, and documented.

3. Definitions

3.1 Hydraulic Conductivity

Hydraulic conductivity is the rate of flow through a unit area cross section under a unit hydraulic gradient, at the prevailing temperature. Hydraulic conductivity typically is reported as feet (ft) per day (reduced from cubic feet/day/square feet [ft^3/day/ft^2]). In the Systems International system, the units are typically cubic meters/day/square meters [m^3/day/m^2] or meters/day. The letter ”K“ is typically used to denote hydraulic conductivity.

3.2 Transmissivity

Transmissivity (T) is the product of the hydraulic conductivity (K) and saturated aquifer thickness (b), and is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in area per time units, typically gallons/day/ft or ft^2/day in the English system. In the Systems International system, transmissivity is given in m^3/day/m or m^2/day.

3.3 Storage Coefficient

Storage coefficient is the volume of water an aquifer releases or takes into storage per unit surface area of the aquifer per unit change in head. Storage coefficient (S) is unitless, and is applied only to confined aquifers. Typical values of storage coefficients range from 10^{-3} to 10^{-5}.

3.4 Specific Yield

Specific yield is the ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity to the volume of that mass. Specific yield (S_y) is applied to unconfined aquifers only. Typical values of specific yield are 10^{-1} to 10^{-3}.

3.5 Confined Aquifer

A confined aquifer is an aquifer that is located between layers of impermeable materials, such as clay, which impede the movement of water into and out of the aquifer. The water level in a well in a confined aquifer usually rises above the top of the aquifer.

3.6 Unconfined Aquifer

An unconfined aquifer is also known as a water table aquifer and is an aquifer in which the water table forms the upper boundary. The water level in an unconfined aquifer lies at the water table.

3.7 Skin Effects

Skin effects are described as an increase or decrease in measured hydraulic conductivity caused by drill cuttings or fluids accumulating along the wall of the boring.

3.8 Hydraulic Boundaries

Hydraulic boundaries are a geologic or hydrologic feature that affects the movement or distribution of groundwater.

3.9 Delayed Yield

Delayed yield is water that drains vertically downward from the newly created unsaturated zone during an unconfined aquifer test, after the water table has been lowered from its initial level.

3.10 Observation Well

An observation well is a well drilled in a select location for the purpose of observing parameters, such as water levels and water quality.

3.11 Pumping Well

A pumping well is a well from which water is withdrawn by pumping in order to evaluate aquifer characteristics by monitoring the response to the pumping action in the pumping or observation wells.

3.12 Well-Bore Storage Effects (Casing Effects)

Well-Bore storage effects are the delayed drawdown responses observed in the initial phases of a pump test due to removal of water from storage in the well casing and filter pack.

4. Responsibilities

The CTO Manager is responsible for selecting the appropriate aquifer test procedures based on the objectives of the test. The CTO Manager is also responsible for ensuring that the work plan defines test methods clearly. The CTO Manager is responsible for ensuring that all personnel involved in aquifer tests shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1b Section 25-5.8 Specific Training Requirements (DON 2002).

QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for supervising the test in the field. Aquifer testing qualifications for the FM include a degree in geology, hydrogeology, hydrology, or civil/environmental engineering with 2 years of experience in conducting aquifer tests and interpreting the results.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 Constant Discharge Aquifer Pumping Tests

Constant discharge aquifer pumping tests are commonly performed at hazardous waste sites to estimate the hydraulic conductivity, transmissivity, specific yield, and/or storativity of an aquifer. These data assist in analyzing contaminant fate and transport, and site remediation options. A wide variety of aquifer test methods and aquifer conditions (e.g., confined, unconfined, leaky) exist and each test must consider both the goals of the test and site conditions.

Pumping tests that are properly designed and implemented can evaluate well efficiency and detect hydraulic boundaries, vertical leakage, or delayed yield effects, and allow assessment of hydraulic conductivity and storativity.

The proper design and implementation of a pumping test requires knowledge of the hydrogeologic setting. Information required prior to the design of the test includes:

- Objectives of the pumping test
- Location of observation and pumping wells
- Climatic conditions
- Screened intervals of all wells
- Installation and completion methods (“as-builts”)
- Generalized hydrogeologic conditions
- Regional groundwater flow direction
- Boundary conditions
- Existence of improperly completed or developed wells

- Presence of pumping or irrigation
- Potential for the capture of insoluble or dissolved contaminants
- Hydraulic conductivity estimate for aquifer
- Presence and location of confining layers
- Potential well water disposal problems
- Potential for tidal effects
- Previous sampling results and development records

The pumping test interpretation method is based upon an analytical solution that considers well and site conditions. The hydraulic response of the aquifer is compared to a theoretical analytical response. Different analytical solutions exist for unconfined and confined aquifers, each taking into account assumptions about test and aquifer conditions. It is important to document the assumptions applied to the interpretation of a particular test. It is beyond the scope of this procedure to provide a detailed explanation of aquifer testing analytical solutions. Several texts that address pumping test theory are included in Section 8, References.

Constant discharge pumping tests provide results that are more representative of aquifer characteristics than those provided by slug tests; however, pumping tests require greater effort and expense. In general, slug testing should be used only in situations where hydraulic conductivity is sufficiently low to preclude a pumping testing.

5.1.1 Interferences and Potential Problems

The conditions that exist at a site during the performance of a pumping test are often far from ideal. Hydrogeologic factors that may be encountered at a site include:

- Localized or regional pumping
- Barometric effects
- Tidal effects
- Aquifer compression (e.g., trains, traffic)
- Boundary effects
- Recharge effects
- Leakage from underlying or overlying aquifers
- Heterogeneous and anisotropic aquifers

Many of these potential complications may be detected during the pre-test period, or anticipated from an examination of existing hydrogeological data.

Information about the location, completion, and development of the pumping and observation wells may be useful in evaluating potential complications. Complicating factors may include:

- Partially penetrating wells

- Improperly completed or developed wells
- Low-permeability conditions that may lead to well-bore storage effects, well dewatering, or slow responding observations wells
- Wells completed within aquitards, possibly designed to evaluate the pressure response and leakage into adjacent aquifers
- Potential skin effects caused by well-bore conditions.

5.1.2 Pumping Test Planning

Prior to implementation of the pumping test, consider:

1. Monitoring pre-test and post-test water levels (preferably for at least 3 days). Groundwater systems are rarely static and localized conditions, such as nearby pumping wells, tidal effects, barometric effects, variable recharge conditions, and other ”non-ideal“ conditions, are likely to be present at a site.
2. The volume of water that will be generated during the test, and storage, treatment, and disposal methods for the water generated during the test for the performance of a long-term, constant discharge pumping test. If free product is present within the vicinity of the pumping well, include an oil–water separator as part of the groundwater treatment process.
3. Observation of well design, location, and installation.
4. Use of subcontractors for installing and operating pumping equipment during constant discharge pumping tests.
5. Selection of pumping equipment.
6. Pump placement in well.
7. Staff scheduling, and security and safety during overnight aquifer testing.
8. How equipment will be decontaminated (Procedure I-F, *Equipment Decontamination*) and how potentially contaminated water will be handled (Procedure I-A-6, *IDW Management*.) Select a well containing uncontaminated groundwater for pump testing. Water derived from a potentially contaminated well may have to be temporarily stored on site. Once the analytical results are obtained, the disposition of the water can be determined. In some instances, flammable/explosive fluids and gases may be collected in which case onsite storage procedures must allow for the hazards of storing these substances. If possible, avoid aquifer tests of highly contaminated wells.

5.1.3 Field Procedures

5.1.3.1 Preparation

1. Review the site work plan (WP), and become familiar with information about the wells to be tested (e.g., depth to water, well depth, aquifer hydraulic conductivity, distances between pumping and observation wells, and anticipated drawdown).
2. Test the operation of all field equipment. Use a data logger for all aquifer testing unless the QA Manager or Technical Director approves other methods. Ensure that the electronic data logger is fully charged. Calibrate the electronic data logger and transducers at measured

depths in a container of water. Always bring additional transducers in case of malfunctions. Calibrate the flow meter at several known discharge rates. Ensure that the calibration is linear in the anticipated test range. Have pH (indicates the hydrogen ion concentration – acidity or basicity) and conductivity meters on site to assess water quality periodically during the pumping test.

3. Assemble a sufficient number of field pumping test forms.
4. Ensure that the pumping well has been properly developed prior to testing.
5. If a flow meter is not operating properly, calibrate an orifice weir, bucket, or other type of water measuring device to accurately measure and monitor discharge from the pumping well.
6. Have sufficient lengths of pipe on hand to transport the discharge from the pumping well to a holding tank or to a discharge point well beyond the influence of the expected cone of depression.
7. Install a gate valve on the discharge pipe to control the pumping rate.
8. Install an outlet at the wellhead to obtain water quality samples during the pumping test.
9. Install a check valve on the pump so water cannot flow back into the well after the pump is shut off.
10. Install transducers in wells, making sure to secure them firmly at the wellhead, and allow sufficient depth for drawdown (generally 5 to 10 feet below the water surface in the well). Measure the depth to the transducer, and ensure that the transducer is not placed at a depth below the water surface beyond its range (this will ruin the transducer).
11. Arrange for treatment, special storage and handling, or a discharge permit before contaminated water is pumped.

Monitor pre-test water levels at the test site for at least 3 days prior to performance of the test. A continuous-recording device is recommended. This information allows the field team to evaluate the barometric efficiency of the aquifer when comparing with barometric readings at the site. It helps to determine if the aquifer is experiencing variations in head with time due to tidal influences or recharge or pumping in the nearby area.

If barometric pressure is found to significantly affect water levels in the aquifer, then record changes in barometric pressure during the test (preferably using an onsite barometer) in order to “correct” water levels for fluctuations that may occur because of changing atmospheric conditions. Trends in pre-test water levels can then be projected for the duration of the test. Correcting water levels during the test produces results that are representative of the hydraulic response of the aquifer caused by pumping of the test well in the absence of atmospheric pressure changes.

The influence of ocean tides or localized pumping can mask the water level response to the pumping test. Water levels can be corrected for the effect of ocean tides by adding or subtracting values of tidal fluctuation from the response of the pumping. Pumping test data can be corrected for the effect of localized pumping if the pumping response prior to the test is known and predictable over the duration of the drawdown and recovery phases of the test. Non-rhythmic and “unique” water-level fluctuations might be difficult to resolve and substantial hydrologic judgment is required to properly interpret the data.

5.1.3.2 STEP DRAWDOWN TEST

Prior to initiating a constant discharge pumping test, conduct a step drawdown test. The purpose of the step drawdown test is to estimate the greatest flow rate that may be sustained during a long-term test. The step drawdown test is typically conducted over a 4- to 8-hour period prior to commencing the constant discharge test.

To correctly assess the maximum yield of the well, pump the well at discharge rates varying from relatively low to the maximum rate that the well can produce. Distribute the discharge increments for each step as evenly as possible through the range of well yields. Utilize four steps for the test. Each step shall last approximately 2 hours depending on the response of water levels to pumping. Measure water level recovery following the test for approximately 8 hours.

Measure water levels periodically during the step test within the pumping well and within observation wells that may be used during the constant discharge test. For each step increment, measure levels within the pumping well on the same time basis as that used for the beginning of the constant discharge test (i.e., approximately on a logarithmic basis). Observation wells may be measured using a longer time scale since the primary reason for measurement is to assess whether the aquifer responds to pumpage rather than to gather data for quantitative analysis. Also measure water levels during the recovery phase of the step test.

Prior to initiating the constant discharge test, analyze the data from the step drawdown test to identify the appropriate discharge rate for the longer-term test. Plot the generated drawdown versus time data on a semilogarithmic graph, and determine the sustainable discharge rate from this graph by projecting the straight line formed by each data set for each step increment to the longer pumping times associated with the constant discharge test. Determine the optimum pumping rate based on the projected drawdowns associated with these longer time periods and the amount of drawdown available in the pumping well. The step drawdown data can also be evaluated more quantitatively using methods described by Birsoy and Summers (1980) and Lohman (1982).

5.1.3.3 CONSTANT DISCHARGE PUMPING TEST

Time Intervals

After the pumping well has fully recovered from the step drawdown test, the constant discharge pumping test may begin (typically 24 hours after step drawdown testing). At the beginning of the test, set the discharge rate as quickly and accurately as possible. Record the water levels in the pumping well and observation wells using a data logger according to Table I-C-4-1 and Table I-C-4-2.

Table I-C-4-1: Pumping Well Measurements

Elapsed Time Since Start of Test (Minutes)	Intervals Between Measurements (Minutes)
0– 10	.5–1
10–15	1
15–60	5
60–300	30
300–1,440	60
1,440–termination	480

Note: Similar time intervals shall be used during water level recovery, with short time intervals at the start of recovery.

Table I-C-4-2: Observation Well Measurements

Elapsed Time Since Start or Stop of Test (Minutes)	Intervals Between Measurements (Minutes)
0–60	2
60–120	5
120–240	10
240–360	30
360–1,440	60
1,440–termination	480

During the early part of the test, station at least one person at the pumping well and at least one other person to handle other pump test logistics. Readings at the wells need not be taken simultaneously. It is very important to accurately measure depth to water readings, and to record readings at the exact time of measurement. Use pressure transducers and electronic data loggers to record water levels in the pumping well and nearby observation wells. Perform manual checks of the depth to water to verify the pressure transducer measurements. In some instances, the pressure transducer may be unstable and "drifting" may occur.

During a pumping test, record the following data on the aquifer test data form (Attachment I-C-4-1):

1. Site Identification - CTO number, site name, well identification number, indication as to whether the well is an observation or pumping well
2. Location - The location of the well in which water level measurements are being taken
3. Distance from Pumping Well - Distance the observation well is from the pumping well in feet
4. Personnel - The company and individual conducting the pump test
5. Test Start Date - The date when the pumping test began
6. Test Start Time - Time, using 24-hour clock, at which a field measurement was taken (e.g., 1030 hours for 10:30 a.m., and 1350 hours for 1:50 p.m.).
7. Test End Date - Same as above
8. Test End Time - Same as above
9. Depth to water, in feet (to an accuracy of 0.01 feet), in the pumping well at the beginning of the pump test
10. Depth to water, in feet (to an accuracy of 0.01 feet), in the observation well at the beginning of the pump test
11. Depth of pressure transducers
12. Average Pumping Rate - Summation of all entries recorded in the pumping rate (gallons/minute [gpm]) column divided by the total number of pumping rate readings

13. Measurement Methods - Type of instrument used to measure depth to water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers)
14. Comments - Appropriate observations or information including notes on sampling
15. Actual time the test started
16. Elapsed Time - Time elapsed since the start of pumping in minutes
17. Depth to Water - Depth to water, in feet (tenths and hundredths of feet), in the observation well at the time of the water level measurement
18. Pumping Rate - Flow rate of pump measured from an orifice weir, flow meter, container, or other type of water measuring device in gal/min

Water Chemistry Measurements

During the pumping test, use portable field-grade water testing equipment to measure parameters at periodic intervals including pH, electrical conductivity, and temperature of the water. These parameters are used to qualitatively evaluate aquifer conditions. Recalibrate water testing equipment during the pump test on a predetermined schedule with known calibration standards.

Test Duration

The duration of the test depends on the properties of the aquifer that the project seeks to characterize. The duration may be determined by plotting the drawdown data on both log-log and semi-log graphs and preliminarily evaluating it during the pump test. Doing this allows possible identification of recharge boundaries or permeability barriers that might be further evaluated with a longer pump test. Optimally, flow conditions should approach steady state where the observed drawdowns reach near-constant values prior to terminating the test.

The minimum time necessary for the test is indicated on the semi-log graph when the log-time versus drawdown for the most distant observation well plots as a straight line (assuming $u < 0.01$) (Jacob's). Longer tests tend to produce more reliable results. Longer tests are usually necessary for unconfined aquifers to allow evaluation of delayed yield effects. A pumping duration of 24 to 72 hours is desirable, followed by a similar period for monitoring the recovery of the water level.

Consider knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives in selecting duration of the test and the effect of boundary conditions. There is little need to continue the test once the increase in drawdown in all observation wells becomes insignificantly small; however, delayed yield effects and boundary effects may be observed with continued pumping.

Recovery

Once the pump has been shut down, record the recovering water levels in the same manner and using the same time intervals as were used during the beginning of the constant discharge test (i.e., at approximately logarithmic time intervals). Monitor recovery for a period corresponding to the length of the pumping portion of the test or when water levels have recovered to 95 percent of their original level. Continue tidal and barometric monitoring during the recovery portion of the test.

5.1.3.4 POST OPERATION

Perform the following activities after completion of water level recovery measurements:

1. Decontaminate and/or dispose of equipment as listed in Procedure I-F, *Equipment Decontamination*.
2. For the electronic data-logger, use the following procedures:
   a. Stop the logging sequence.
   b. Print data, or
   c. Save memory at the end of the day's activities.
3. Replace the testing equipment in storage containers.
4. Check the sampling equipment and supplies, and repair or replace all broken or damaged equipment.
5. Replace expendable items.
6. Return equipment to the Equipment Manager, and report malfunctions or damage.
7. Review field forms for completeness.
8. Interpret slug or aquifer test field results with the Project Hydrogeologist and/or CTO Manager. Analyze the slug test using appropriate software packages or graphical solutions.

5.1.4 Pumping Test Interpretation

There are several accepted methods for determining aquifer properties, such as transmissivity, storativity, and hydraulic conductivity. Kruseman and de Ridder (1990) and Freeze and Cherry (1979) present methods of interpretation; however, the appropriate method depends on the characteristics of the aquifer being tested (e.g., confined, unconfined, leaky confining layer). When reviewing pumping test data, generate both log-log and semi-log plots of drawdown with time. Log-log plots, however, cannot be used for quantitative analysis of data obtained from the pumping well.

The interpretation of pumping test data attempts to match or duplicate the observed field response with a theoretical water level response to pumping. Aquifer parameters can be estimated on the basis of such a match using commercially available software such as AQTESOLV.

A range of aquifer parameter values are likely to occur at a site. For example, hydraulic conductivities are typically log normally distributed. The estimate of the values may vary with the interpretation method. It is important to verify that the assumptions used to derive a particular method of solution are reasonable in view of the test conditions. For example, storativity values should be less than 0.005 for a confined aquifer.

5.1.5 Quality Assurance/Quality Control

Calibrate all gauges, transducers, flowmeters, and similar equipment used for conducting pumping tests before use at the site. Obtain copies of the documentation of instrumentation calibration, and file them with the test data records. The calibration records shall consist of laboratory measurements and, if necessary, any onsite zero adjustment and/or calibration performed. Where possible, check all flow and measurement meters on site using a container of measured volume and a stopwatch. Verify the accuracy of the meters before testing proceeds. Also verify the water levels measured by a pressure transducer-based data logger by manual measurements.

5.2 SLUG TESTS

5.2.1 Scope and Application

A common procedure for single-well hydraulic testing is a slug test. A slug test is restricted in application because it is a measure of the well and near-well hydrogeologic conditions. The results of the test provide an order of magnitude estimate of the horizontal hydraulic conductivity of the aquifer, and are most useful in low-permeability materials. This method cannot determine storativity very accurately.

5.2.2 Method Summary

A slug test involves the instantaneous injection or withdrawal of a mass (slug) of water or object that displaces a known volume of water into or from a well, and measuring the induced water level fluctuation.

The primary advantages of using slug tests to estimate hydraulic conductivities are that: (1) estimates can be made *in situ*, thereby avoiding errors incurred in laboratory testing of disturbed soil samples; (2) tests can be performed quickly at relatively low cost because only one observation well is required; and (3) the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay). Slug tests cannot reliably establish estimates of storativity or specific storage. Use slug tests only to evaluate water-bearing zones with relatively low hydraulic conductivities. In addition, always conduct slug testing with a data logger coupled to a pressure transducer.

5.2.3 Interferences and Potential Problems

The zone of investigation covered by a slug test is limited to the immediate vicinity of the well bore. Thus, interpretation of the test may be strongly influenced by the hydraulic properties of the well casing, filter pack, and borehole, and may possibly reflect variations in well development. When possible, use consistent methods of well construction and development at a site to minimize the potential for variation in slug test results.

Problems associated with pump tests may affect a slug test. Refer to Section 5.1.1 for further discussion.

Water levels within a borehole will often oscillate rapidly after the introduction/withdrawal of a slug volume. This does *not* indicate a problem with performance of the slug test. If a well is screened above and below the water table, a slug injection method will tend to store water in the filter pack and yield a higher estimate of hydraulic conductivity than would be expected. In these cases, the slug withdrawal method may yield more accurate data.

5.2.4 Field Procedures

5.2.4.1 PREPARATION

Office Procedures

1. Review the WP and the procedure, including well construction, development, and sampling information on the wells to be tested.
2. Review the operator's manual provided with the electronic data-logger.
3. Verify the displacement volume of the slug. This may be accomplished by accurately measuring the dimensions of a solid displacement slug or by accurately measuring the volume of water discharge from a liquid slug.
4. Ensure the proper operation of all field equipment. Ensure that the electronic data-logger is fully charged. Test the electronic data-logger using a container of water (e.g., sink, bucket of water). Bring additional transducers to the site in case of malfunctions.
5. Assemble a sufficient number of field forms to complete the field assignment.
6. Assemble the appropriate testing equipment.

Equipment List

Decontaminate and test all equipment prior to commencing field activities. The following equipment is needed to perform slug tests:

- Tape measure (subdivided into tenths of feet)
- Water pressure transducer
- Electric water level indicator or steel tape (subdivided into hundredths of feet)
- Electronic data-logger
- Solid or liquid slug of a known volume (stainless steel, polyvinyl chloride, and ABS plastic are appropriate construction materials)
- Watch or stopwatch with second hand
- Semi-log graph paper
- Water proof ink pen and logbook
- Temperature/pH/electrical conductivity meter (optional)
- Appropriate references and calculator
- Electrical tape
- Health and safety equipment, as required

Data Form

Use the slug test data form to record observations. Make all entries in indelible ink. The form shall include the following data:

- Site identification – the identification number assigned to the site and the well
- Date – the date when the test data were collected: year, month, and day (e.g., 960901 for 1 September 1996)

- Slug Volume (ft^3) – manufacturer's specification for the known volume or displacement of the slug device
- Logger – identifies the company or person responsible for performing the field measurements
- Test Method – either injected (dropped) or withdrawn (pulled out) from the monitoring well
- Comments – appropriate observations or information for which no other blanks are provided
- Depth to Water (ft) – Depth of water recorded to 0.01 feet
- Configuration of the Data-Logger (e.g., sample rate, duration, transducer type)

5.2.4.2 PERFORMING THE SLUG TEST

Use the following procedures to collect and report slug test data. They may be modified to reflect specific site conditions:

1. Store all data internally or on computer diskettes or tape using the electronic data-logger and pressure transducer. Transfer the data to a computer for analysis. Keep a computer printout of the data in the field as documentation.
2. Decontaminate the transducer and cable.
3. Collect initial water level measurements from monitoring wells in an upgradient to downgradient sequence, if possible.
4. Before beginning a slug test, record information and enter it into the electronic data-logger. The type of information will vary depending on the model used. Consult the operator's manual for the proper data entry sequence.
5. Test wells from least contaminated to most contaminated, if possible.
6. Determine the static water level in a well by measuring the depth to water periodically for several minutes.
7. Cover sharp edges of the well casing with duct tape to protect the transducer cables.
8. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test, but at least 2 feet from the bottom of the well. Be sure this depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at constant depth.
9. Connect the transducer cable to the electronic data-logger.
10. Enter the initial water level and transducer design range into the recording device according to the manufacturer's instructions (the transducer design range will be stamped on the side of the transducer). Compare manual and pressure transducer measurements to check that the transducer is operational and accurate. Thermal drift may occur until the transducer equilibrates with the water in the well. Record the initial water level on the recording device.
11. "Instantaneously" inject or withdraw a known volume (slug) of water to the well. The preferred test method is to introduce a solid cylinder of known volume to displace and raise the water level. Let the water level re-stabilize, and remove the cylinder. It is important to

inject or withdraw the volumes as quickly as possible because the analysis assumes an “instantaneous” change in volume is created in the well.

12. Measure and record the depth to water and the time using the data-logger, with the moment of volume injection or withdrawal assigned time zero. The number of depth-time measurements necessary to complete the test is variable and can be determined from previous aquifer tests or evaluations. It is critical to make as many measurements as possible in the early part of the test.
13. Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth.
14. Retrieve the slug (if applicable), and follow appropriate decontamination procedures.

The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation, and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

If the well is to be used as a monitoring well, take precautions to ensure that the well is not contaminated by material introduced into the well. If water is added to the monitoring well, clean it from an uncontaminated source, and transport it in a clean container. Clean bailers or measuring devices prior to the test. If tests are performed on more than one monitoring well, take care to avoid cross-contamination of the wells.

Conduct slug tests on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the static water level prior to testing.

5.2.4.3 Post Operations

Decontaminate and/or dispose of equipment according to Procedure I-F, *Equipment Decontamination*.

Implement the following procedure for the electronic data-logger:

1. Stop the logging sequence.
2. Print the data, if available.
3. Save the data, and disconnect the battery at the end of the day’s activities.
4. Inventory sampling equipment and supplies, and repair or replace broken or damaged equipment.
5. Replace expendable items.
6. Return equipment to the Equipment Manager, and report malfunctions or damage.
7. Review field forms for completeness.

8. Interpret slug test field results with the Project Hydrogeologist and/or the CTO Manager. Analyze the slug test using appropriate software packages or graphical solutions.
9. Send data-logger or pressure transducers to factory for recalibration, if needed.

5.2.5 Slug Test Interpretation

The results of slug tests should be viewed as order of magnitude estimates of hydraulic conductivity and should not be performed as a substitute for constant discharge pump tests. The interpretation of the water level response usually requires a number of simplifying assumptions, and the physical properties of the well casing and filter pack are rarely included in the analysis. A limited number of test interpretation methodologies exist. The following two approaches are most commonly used:

1. Cooper et al. Method (Cooper, Bredenhoeft, and Papadopulos 1967, Papadopulos, Bredenhoeft, and Cooper 1973) – The U.S. Geological Survey developed a more physically based model for the slug test. It involves a curve-fitting procedure that may not always produce a unique fit and is the only method discussed herein to produce an estimate of specific storage.
2. Bouwer and Rice Method (Bouwer 1989, Bouwer and Rice 1976) – This is a popular approach to the interpretation of slug test data obtained from unconfined aquifers. It is a graphical method and relatively straightforward to apply.

5.2.6 Quality Assurance/Quality Control

The QA/quality control procedures for slug tests are similar to the pumping test analysis (Section 5.1.5).

6. Record Keeping Requirements

All data collected in the field shall be maintained onsite during field activities, and then transferred to the office project files upon completion of the aquifer test(s). Computerized data (e.g., from data-loggers) shall be stored in ASCII format. The CTO Manager or designee shall review all aquifer test forms upon completion of the aquifer test(s).

7. Health and Safety

Standard health and safety practices should be observed as stated in the site-specific health and safety plan (HSP). Prior monitoring should have determined contaminant concentrations and, thus established any required personal protective equipment (PPE).

Suggested minimum protection during aquifer test activities shall include inner disposable vinyl gloves, outer chemical protective nitrile gloves, rubberized steel-toed boots, and an American National Standards Institute-standard hard hat. Half-face respirators and cartridges and Tyvek suits may be necessary depending on the contaminant concentrations and shall always be available on site.

Depending upon the type of contaminant expected or determined in previous sampling efforts, employ the following safe work practices:

7.1 PARTICULATE OR METAL COMPOUNDS

- Avoid skin contact with and/or incidental ingestion of water.
- Wear long-sleeved protective gloves and splash protection (i.e., Saranex or splash suits and face shields), as warranted.

7.2 VOLATILE ORGANIC COMPOUNDS

- Avoid breathing constituents venting from the tanks by approaching upwind, and/or by use of respiratory protection.
- Survey the well headspace and the personnel breathing zone with a flame ionization detector/photoionization detector prior to and during sampling.
- If monitoring results indicate organic vapors that exceed action levels as specified in the site-specific HSP, sampling activities may need to be conducted in Level C protection. At a minimum, skin protection will be required by use of Tyvek or other media that is protective against the media being encountered.

7.3 FLAMMABLE OR EXPLOSIVE CONDITIONS

- Periodically monitor flammable or explosive gases using an explosimeter and oxygen meter.
- Place all ignition sources upwind or crosswind of the well or borehole (i.e., generators).
- If explosive gases exceed the designated action levels as specified in the site-specific HSP, cease operations and evaluate conditions.

7.4 PHYSICAL HAZARDS ASSOCIATED WITH AQUIFER TESTING

- To avoid back injuries associated with moving generators and pumps, always use two people and the large muscles of the legs, not the back.
- To avoid slip/trip/fall (wet) conditions as a result of leaking pumps or discharge, use textured boots/boot cover bottoms.
- To minimize fire/explosion hazards, follow the following guidelines:
  - Use monitoring equipment, such as explosimeters, to detect flammable/explosive atmospheres.
  - Keep all potential ignition sources out of the work area.
  - Keep two generators on site and gassed up alternately when the engines are cool—the filling of generators with fuel while they are running is strictly prohibited.
  - Keep at least one ABC- or BC-rated fire extinguisher within 75 feet of the work area to prevent the spread of small fires should they occur.
- Conduct all work being performed at night in areas where lighting equals or exceeds five foot-candles.
- Personnel should avoid climbing on tanks as much as possible to eliminate the possibility of injuries due to falls.

- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1-2 cups/hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.

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Procedure I-F, *Equipment Decontamination.*

9. Attachments

I-C-4-1: Aquifer Test Data Form

Attachment I-C-4-1
Aquifer Test Data Form

AQUIFER TEST DATA FORM

PROJECT NAME: ____________________ PROJECT NUMBER: ________________ WELL NUMBER: _________________

LOCATION: ____________________ DATE: ________________ HYDROGEOLOGIST: ______________________________

PUMPED WELL NO. _____ DISTANCE FROM PUMPING WELL: _________ TYPE OF TEST: ________ TEST NO. _____________

MEASURING EQUIPMENT _____________________________ TYPE AND DEPTH OF PUMP ____________________________________

Time Data **Pump on: Date___Time ___ ( )** **Pump off: Date___Time___ ( )** **Duration of aquifer test:** **Pumping___Recovery____**					**Water Level Data** **Static Water Level _______________** **Measuring Point_________________** **Elevation of measuring point_______**				**Discharge Data**	**Water Quality Data**			**Comments on factors affecting test data**
Date	Clock Time	Time since pump started t (min)	Time since pump stopped t (min)	Vt	Depth of Water (feet)	Pressure (PSI)	Accumulated Drawdown (feet)	Corrected Drawdowns (feet)	Flow Rate (gpm)	pH	Specific Conduc-tivity	Temp (°C)	

Appendix B

Guidance for Data Deliverables and Development of Data Usability Summary Reports

Appendix 2B
Guidance for Data Deliverables and the Development of
Data Usability Summary Reports

1.0 Data Deliverables

(a) DEC Analytical Services Protocol Category A Data Deliverables:

1. A Category A Data Deliverable as described in the most current DEC Analytical Services Protocol (ASP) includes:

i. a Sample Delivery Group Narrative;

ii. contract Lab Sample Information sheets;

iii. DEC Data Package Summary Forms;

iv. chain-of-custody forms; and,

v. test analyses results (including tentatively identified compounds for analysis of volatile and semi-volatile organic compounds)

2. For a DEC Category A Data Deliverable, a data applicability report may be requested, in which case it will be prepared, to the extent possible, in accordance with the DUSR guidance detailed below.

(b) DEC Analytical Services Protocol Category B Data Deliverables

1. A Category B Data Deliverable is includes the information provided for the Category A Data Deliverable, identified in subdivision (a) above, plus related QA/QC information and documentation consisting of:

i. calibration standards;

ii. surrogate recoveries;

iii. blank results;

iv. spike recoveries;

v. duplicate results;

vi. confirmation (lab check/QC) samples;

vii. internal standard area and retention time summary;

viii. chromatograms;

ix. raw data files; and

x. other specific information as described in the most current DEC ASP.

2. A DEC Category B Data Deliverable is required for the development of a Data Usability Summary Report (DUSR).

2.0 Data Usability Summary Reports (DUSRs)

(a) Background. The Data Usability Summary Report (DUSR) provides a thorough evaluation of analytical data with the primary objective to determine whether or not the data, as presented, meets the site/project specific criteria for data quality and data use.

1. The development of the DUSR must be carried out by an experienced environmental scientist, such as the project Quality Assurance Officer, who is fully capable of conducting a full data validation. The DUSR is developed from:

i. a DEC ASP Category B Data Deliverable; or

ii. the *USEPA Contract Laboratory Program National Functional Data Validation Standard Operating Procedures for Data Evaluation and Validation*.

2. The DUSR and the data deliverables package will be reviewed by DER staff. If full third party data validation is found to be necessary (e.g. pending litigation) this can be carried out at a later date on the same data package used for the development of the DUSR.

(b) Personnel Requirements. The person preparing the DUSR must be pre-approved by DER. The person must submit their qualifications to DER documenting experience in analysis and data validation. Data validator qualifications are available on DEC's website identified in the table of contents.

(c) Preparation of a DUSR. The DUSR is developed by reviewing and evaluating the analytical data package. In order for the DUSR to be acceptable, during the course of this review the following questions applicable to the analysis being reviewed must be answered in the affirmative.

1. Is the data package complete as defined under the requirements for the most current DEC ASP Category B or USEPA CLP data deliverables?

2. Have all holding times been met?

3. Do all the QC data; blanks, instrument tunings, calibration standards, calibration verifications, surrogate recoveries, spike recoveries, replicate analyses, laboratory controls and sample data fall within the protocol required limits and specifications?

4. Have all of the data been generated using established and agreed upon analytical protocols?

5. Does an evaluation of the raw data confirm the results provided in the data summary sheets and quality control verification forms?

6. Have the correct data qualifiers been used and are they consistent with the most current DEC ASP?

7. Have any quality control (QC) exceedances been specifically noted in the DUSR and have the corresponding QC summary sheets from the data package been attached to the DUSR?

(d) Documenting the validation process in the DUSR. Once the data package has been reviewed and the above questions asked and answered the DUSR proceeds to describe the samples and the analytical parameters, including data deficiencies, analytical protocol deviations and quality control problems are identified and their effect on the data is discussed.