Attachment II

Site-Specific Sampling and Analysis Plan
Remedial Investigation
Waste Water Treatment Plant No. 1 Sewer Lines

Former Plum Brook Ordnance Works, Sandusky, Ohio

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List of Acronyms

AOC	area of concern
ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
DNT	dinitrotoluene
DOD	U.S. Department of Defense
DQO	data quality objective
Eh	oxygen-reduction potential
EM	electromagnetic technology
EPA	U.S. Environmental Protection Agency
FADL	field activity daily log
GPR	ground-penetrating radar
GPS	global positioning system
IDW	investigation-derived waste
LEL	lower explosive limit
MG	magnetic gradiometry
mL/min	milliliters per minute
NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
OD	outside diameter
OEPA	Ohio Environmental Protection Agency
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PID	photoionization detector
PPE	personal protective equipment
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RBSC	risk-based screening concentration
RI	remedial investigation
SAIC	Science Applications International Corporation

List of Acronyms (Continued)

Shaw	Shaw Environmental, Inc.
SSAP	site-specific sampling and analysis plan
SWSHP	site-wide safety and health plan
SVOC	semivolatile organic compound
TNT	trinitrotoluene
TNTA	TNT Area A
USACE	U.S. Army Corps of Engineers
WWTP1	Waste water Treatment Plant No. 1

1.0 Project Description

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at previously owned U.S. Department of Defense (DOD) properties. The former Plum Brook Ordnance Works (PBOW) is located in Sandusky, Erie County, Ohio (Figure 1-1). PBOW is being investigated under the Defense Environmental Restoration Program for Formerly Used Defense Sites. The investigation is being managed and technically overseen by the Nashville and Huntington Districts of the U.S. Army Corps of Engineers (USACE). This 9,000-acre facility was used for the manufacture of explosives during World War II. The site is currently owned by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station of the John Glenn Research Center at Lewis Field.

This site-specific sampling and analysis plan (SSAP) has been prepared by Shaw Environmental, Inc. (Shaw) for the fieldwork to be carried out in support of the remedial investigation (RI) for the waste water sewer lines which extended from the former TNT Area A (TNTA) to the former Waste water Treatment Plant No. 1 (WWTP1). This SSAP is Attachment II of the site-wide sampling and analysis plan (SWSAP) (Shaw, 2008a). It was developed in accordance with the PBOW site-wide sampling and analysis plan (SWSAP) (Shaw, 2008a) and the quality assurance project plan (QAPP) (Shaw, 2008b) to ensure that work performed at the subject site will be of the quality required to satisfy the overall and site-specific project objectives. A site-wide accident prevention/site-wide safety and health plan (Shaw, 2008c) has also been prepared for this investigation to help provide a safe work environment.

1.1 PBOW Facility History

The PBOW site was built in early 1941 and manufactured 2,4,6- trinitrotoluene (TNT), dinitrotoluene (DNT), and pentolite. Production of explosives began in December 1941 and continued until 1945. After the plant was shut down, decontamination of TNT, acid, pentolite, and DNT processing lines began; decontamination was completed by the Army during the last quarter of 1945. The property was under the supervision of the Army Ordnance Department. The War Assets Administration accepted custody of the property (3,230 acres) except for the retained area known as the magazine area (2,800 acres) in 1946. The Department of the Army reacquired the 3,230 acres in 1954 and performed cleanup efforts during the 1950s through 1963. Two property use agreements were entered into by the National Advisory Committee of Aeronautics, the predecessor of NASA, and the Army in 1956 and 1958, respectively. In 1963, accountability and custody of the entire PBOW property (6,030 acres) was transferred to NASA

by the Department of the Army. NASA has operated and maintained PBOW since 1963, and it is currently the NASA Glenn Research Center, Plum Brook Station.
Figure 1-2 shows various PBOW areas of concern, including WWTP1 and TNTA. It is noted that TNTA has been investigated extensively, and a TNTA feasibility study has been conducted (Shaw, 2003). WWTP1 has been investigated separately, and further investigation of WWTP1 is planned for the fall of 2008. This SSAP focuses exclusively on the WWTP1 sewer lines.

1.2 WWTP1 Sewer Line Description and History

During production in the 1940s, three waste water treatment plants were used to process production waste water from the three TNT manufacturing areas at PBOW. The wastes were accumulated in the settling basins of the TNT manufacturing areas. These wastes were transported to the waste water treatments plants via aboveground and belowground wood-stave sewer lines (USACE, 1995). Chemicals in the waste streams included sodium salts of sulfite, sulfate, nitrite, and nitrate; sulfonates of unwanted TNT isomers; trinitrobenzoic acid; trinitrobenzaldehyde; trinitrobenzyl alcohol; nitrotoulenes; and dinitrotoluenes (Dames and Moore, Inc., 1996).

The manufacturing areas were denoted TNT Area A, TNT Area B, and TNT Area C; the waste water treatment plants were denoted WWTP1, Waste water Treatment Plant No. 2, and Waste water Treatment Plant No. 3. WWTP1 received waste water from TNTA to the east and from TNT Area B to the south. This SSAP includes the two sewer lines that reportedly extended between TNTA and WWTP1, because it has been reported that portions of these sewer lines may still be present (USACE, 1995).

The locations of the two sewer lines originally extending from TNTA to WWTP1, approximated from historical as-built maps (Trojan Powder Company, 1944), are shown on Figure 1-3. One line was a 4-inch diameter line that extends due west from the TNTA settling basins (Building 187) for approximately 2,700 feet before angling southwest to WWTP1. A 1944 drawing indicates that a roughly 500-foot section of this wood-stave line, just west of Taylor Road, is 5 inches in diameter. The other sewer line, 6 inches in diameter, extended directly west-southwest from the TNTA settling basins for approximately 3,800 feet to WWTP1. Note that wood-stave pipes were constructed of small wood slats (i.e., staves) joined together in a tongue-and-groove fashion and reinforced with steel banding. Use of wood-stave pipes was not uncommon for water and sewage conveyance during the late 1800s until the 1950s.

No specific investigation has been conducted at PBOW concerning the WWTP1 sewer lines.

During PBOW operations, the sewer lines reportedly often became clogged with TNT residue, and in some instances were completely plugged. The plugged lines were abandoned, and larger diameter bypass sewer lines were constructed around the blocked areas to provide continual drainage of the waste water (USACE, 1995).

Dames & Moore, Inc. (1997) reported that approximately 1,050 feet of the WWTP1 sewer line leading due west from the TNTA settling basins was removed and burned. It was also reported by Dames & Moore, Inc. (1997) that the 6-inch wooden WWTP1 sewer line which extends several thousand feet west-southwest of the TNTA settling basins was intact.

Apparent discrepancies exist as to the diameters of the sewer lines. Dames & Moore, Inc. (1997) confirms the as-built drawings (Trojan Powder Company, 1944) that the sewer extending south-southwest of TNTA is a 6-inch-diameter wooden pipe, whereas the site management plan (USACE, 1995) makes no mention of the existence of a 6-inch-diameter pipe in association with TNTA. However, it may be that the lengths and diameters of pipes reported for TNTA refer only to those which were removed and burned.

1.3 Site-Wide Hydrogeology

Two hydrolithologic units are known to exist at PBOW. The overburden unit, composed of glacial outwash materials, has a thickness ranging from a few feet in the south to more than 40 feet in some locations in the north. Based on data from monitoring wells installed closest to the area of concern (AOC), the overburden thickness near the WWTP1 sewer lines is expected to be around 16 to17 feet, with the water-bearing interval expected to be at 8 feet below the ground surface (bgs). Overall, the water-producing capacity of the overburden materials is strongly controlled by seasonal changes, and varies spatially across the PBOW facility (IT Corporation [IT], 1999). The overburden in the vicinity of the WWTP1 sewer lines is initially underlain by the Plum Brook Shale followed by the Delaware Limestone. The shale bedrock is expected to be encountered at depths ranging from 15 to 20 feet at the WWTP1 sewer lines. Both the Plum Brook Shale and Devonian Limestone dip to the southeast at approximately 35 feet per mile.

In general, groundwater flows in a northerly direction, towards Lake Erie, in both the unconsolidated overburden/shale material and the underlying limestone bedrock. However, on the western side of the installation, groundwater in the overburden/shale water-bearing zone flows to the northwest, while groundwater in the bedrock aquifer flows to the northeast. Both the overburden/shale and deeper limestone groundwater are expected to flow toward the northeast.

2.0 Scope of Work and Objectives

2.1 Scope of Work

As specified in the scope of work (USACE, 2008), RI field activities covered by this SSAP consist of the following tasks:

- Geophysical survey
- Trenching
- Soil sampling (from trench and using direct-push)
- Installation of temporary piezometers and monitoring wells
- Groundwater sampling of piezometers and wells
- Laboratory analysis of soil and groundwater samples
- Management and disposal of investigation-derived waste (IDW)
- Preparation and submittal of a geographic information system deliverable
- Preparation of an electronic data deliverable.

The above activities, analytical data, and evaluation will be presented in a site characterization report.

2.2 Objectives

The primary objective of the WWTP1 sewer lines investigation is to determine the soil and overburden groundwater quality and the extent of contamination in soil and groundwater along the WWTP1 sewer lines. Specific objectives of the continued RI are summarized as follows:

- Define site physical features and characteristics.

- Determine nature and extent of DOD-related contamination in soil and groundwater along the WWTP1 sewer lines.

- Determine chemical characteristics of contamination.

- Evaluate fate and transport of contamination.

- Determine if overburden groundwater underlying the AOCs is in sufficient volume and quality to be defined as a potential drinking water source in the state of Ohio.

- Obtain site data of quality, quantity, and distribution appropriate for site characterization, risk assessment, and feasibility study.

2.3 Site-Specific Data Quality Objectives

2.3.1 Overview

The data quality objectives (DQO) process followed during the planning stages of the RI evaluated data requirements needed to support the decision-making process and select the best action to satisfy these requirements. Incorporated components of the DQO process, described in the EPA publication 9355.9-01 *Data Quality Objectives Process for Superfund* (EPA, 1993), are discussed in detail in Section 3.3 of the SWSAP. Determining factors for procedures necessary to satisfy investigative objectives and to establish the basis of future actions at PBOW are presented in Figure 2-2 of the SWSAP (Shaw, 2008a).

2.3.2 Data Users and Available Data

A site-specific conceptual model developed using existing data helped to identify data gaps. During the project planning process, effective methodologies for filling the data gaps were designed and reviewed by the data users with the most efficient data collection design implemented. The SSAP records the rationale for the design, including the location, number, and type of samples necessary to fill the data gaps and to satisfy the DQOs. The SSAP, along with companion documents, provides the regulatory agencies with sufficient detail that they can conclude whether the investigative effort is adequate to satisfy the study objectives.

2.3.3 Conceptual Site Model

Four factors considered in defining the conceptual model (USACE, 2008) for the RI are as follows:

- Potential contaminant sources
- Migration pathways
- Potential receptors
- Types of contaminant of an effected media.

A source of contamination at PBOW is past TNT manufacturing activities, including the production and storage of raw materials. Sources at the proposed areas of investigation result from TNT and DNT disposal activities. The migration pathways for potential contaminants include groundwater and/or bedrock groundwater, soil, sediment, and surface water runoff to creeks. Potential ecological receptors along the WWTP1 sewer lines are wildlife communities, plant communities, and aquatic communities associated with creeks. Exposure of humans to potential contaminants under current land use at PBOW is unlikely, since the site is a secure NASA research station and any contamination would be expected to be below the surface, away from potential contact. If surface soil is found to have been impacted by the sewer lines, then hunters are the most likely current receptors with respect to this medium, as hunting is permitted in part of the area through which the sewer line traces pass. The assumption for future land use is unrestricted. Future off-site residents are assumed to be exposed to current groundwater concentrations via migration of contaminants in groundwater. Potential receptors near the facility include off-site water users. Note that groundwater in the vicinity of the site is not used as a potable source. Chemicals of potential concern, based on past use of PBOW, should primarily be nitroaromatic explosives, but may also include volatile organic compounds, semivolatile organic compounds (SVOC), metals, and pesticides/polychlorinated biphenyls (PCB).

2.3.4 Decision-Making Process, Data Uses, and Needs

The decision-making process that will be followed during the RI, presented in detail in Section 3.3.4 of the SWSAP (Shaw, 2008a), consists of a seven-step process. Data uses and needs are summarized in Table 2-1.

2.3.5 Risk-Based Evaluation

Confirmation of contamination during the RI will be based upon a comparison of detected contaminants in samples from this investigation to the most current risk-based screening concentrations (RBSC). Groundwater RBSCs are currently derived from U.S. Environmental Protection Agency (EPA) (2004) preliminary remediation goal (PRG) tap water criteria, and soil RBSCs are derived from residential soil PRGs. Depending on further PBOW team discussion and potential future agreements, the Regional Screening Levels (Oak Ridge National Laboratory-EPA, 2008) may be used to derive RBSCs in the future rather than PRGs. Definitive data will be used to determine whether the established guidance criteria are exceeded in the media. These definitive data will be adequate for confirming the presence of the contamination and for supporting a risk assessment and, if necessary, a feasibility study.

2.3.6 Data Quality, Types, and Quantities

Groundwater and soil samples will be collected and analyzed to meet the objectives of the RI. Quality assurance (QA)/quality control (QC) samples will be collected for all sample types described in Chapter 3.0 of this SSAP (Table 2-2). All samples will be analyzed by EPA-approved methods and will comply with EPA definitive data requirements. In addition to meeting the quality needs of the RI, data analyzed at this level of quality are appropriate for all phases of the RI and risk assessments.

2.3.7 Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity

Laboratory requirements of precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) for all samples generated during the RI are provided in Chapter 3.0 of the QAPP (Shaw, 2008c). Tables 7-1 through 7-5 of the QAPP list the laboratory reporting limits (sensitivity). Table 9-1 of the QAPP addresses the laboratory requirements and laboratory QC parameters that effect PARCCS.

3.0 Field Activities

The continued RI approach will be consistent with work conducted previously at the PBOW facility. Briefly, geophysical survey activities will be used to locate the WWTP1 sewer lines. A series of trenches will be installed to confirm the sewer line locations, inspect their condition, and provide access for sampling of associated soil. Direct-push soil samples will be collected from along the sewer lines, their locations dependent upon the analytical results of the trench samples. A temporary piezometer will be installed in each boring. Three overburden/shale and three limestone monitoring wells will be installed after the review of the analytical results of the piezometers. Thus, field activities under this SSAP will include the following:

- Geophysical survey activities to locate the WWTP1 sewer lines
- Installation of 30 test pits to confirm the presence of the WWTP1 sewer lines, inspect their condition; and provide access for sampling of associated soil
- Sampling of soil underlying the sewer lines from the test pits, 1 sample for each of 30 test pits
- Collection of 2 soil samples at each of 10 direct-push soil boring locations along the WWTP1 sewer lines
- Installation of piezometers in each of 10 borings along the sewer lines
- Sampling of groundwater from the piezometers
- Installation of three overburden/shale and three limestone monitoring wells along the sewer line
- Sampling of the monitoring wells
- Management and disposal of IDW.

All boring and well locations will be sketched and surveyed; land elevations will be surveyed to within ± 0.01 foot referenced to the National Geodetic Vertical Datum of 1929, and horizontal coordinates will be to the nearest 0.1 foot and referenced to the State Plane Coordinate System (Section 3.4). A notch will be filed into the top of the well/piezometer riser or the top of the riser will be otherwise marked to serve as a vertical and horizontal measuring point. One edge of each test pit location above the approximate center of the pipe will likewise be surveyed. Any site clearing that may be necessary for equipment access, as well as utility clearances prior to intrusive activities (Section 3.5), will be coordinated with NASA.

3.1 Geophysical Survey

3.1.1 Geophysical Survey Approach

A geophysical survey will be completed using either electromagnetic technology (EM) or magnetic gradiometry (MG) to locate the WWTP1 sewer lines, coupled with subsequent confirmation using ground-penetrating radar (GPR). First, the survey team will walk the approximate trace of the WWTP1 sewer lines to review topographic, vegetation, and access issues and identify to what extent these factors may affect the survey. A pilot test will be performed early during the survey activities to determine which of the approaches, EM or MG, is more effective at locating the sewer lines. This pilot test will be conducted near the TNTA settling basins pump house, as this is thought to be an area where the sewer lines should be most shallow and easiest to find. After running several transects with EM and MG (described in Section 3.1.2), the most effective instrumentation will be selected for use throughout the remainder of the survey. Each EM or MG transect will be approximately 50 feet long and 100 feet apart, aligned perpendicularly to each sewer line. EM or MG data will be collected at 1-second intervals.

Anomalies observed using EM or MG will be field-checked immediately following the survey to differentiate between those caused by surface and subsurface sources. For either EM or MG, color-enhanced contour maps will be generated in the field using the GEOSOFT® geophysical mapping system. The contour maps will be used to illustrate subtle anomalies. The anomalies verified as being caused by subsurface objects thought to represent these sewer lines will be recorded on the field interpretation map and marked in the field for further characterization with GPR.

GPR will be used to confirm the anomalies identified with EM or MG. This technology will be used within each EM or MG transect. The GPR transects will generally be shorter than the EM or MG transects because it is anticipated that the GPR survey will focus on the anomalies identified during the EM or MG survey that appear to be potentially indicative of the presence of the wood-stave pipe. If neither the EM or MG is effective in locating the sewer lines, GPR will still be tried, but it is doubtful that GPR alone would prove useful in locating the sewer lines.

Prior to collecting survey data, the GPR will be field checked at a GPR/utility locator base station. This base station will be established where subsurface utilities and their depths bgs are known. Initially, several test GPR profiles will be acquired with the 200- and 400-megahertz antennae along lines perpendicular to the known orientation of the buried utility at the

GPR/utility locator base station. This test data will be used to determine which antenna is more effective and will be used to confirm the WWTP1 sewer line anomalies. GPR parameters specific to the antenna (chosen at the base station) will be recalled and used during data acquisition, unless site-specific conditions indicate modifications should be made to the previously chosen parameters.

GPR profile data will be collected semicontinuously (24 scans per second) as the antenna is towed across the survey lines. A marker switch on the antenna unit will be used to mark control points on the GPR records. The GPR data will be field reviewed in real time on a color monitor. GPR data processing will be performed, as necessary, using RADAN interpretation software. Processing will be conducted to enhance features of interest and maximize the signal-to-noise ratio.

GPR records will be evaluated to determine the depth of penetration at each site and to determine the lateral extent and approximate depth (bgs) of anomaly source materials. The interpreted locations of source materials will be placed on the geophysical interpretation map and marked in the field, as required.

EM or MG and GPR data will be downloaded to a personal computer in the field as the survey progresses and reviewed in the field to assess data quality. The field data files and selected data will be recorded on the field activity daily log (FADL). Pre- and post-survey quality checks will be performed to assure that the survey equipment is performing properly. All data collected by Shaw will be in accordance with the work plan for the site, T-GS-041 Surface Geophysics Standard Operating Procedures, and all documentation will be provided. The geologist/geotechnical engineer will provide the results of the geophysical survey to USACE along with recommendations for locations of test pit excavations.

3.1.2 Geophysical Survey Equipment

3.1.2.1 EM Equipment

Frequency domain EM survey equipment, such as the Geonics EM-31 Terrain Conductivity Meter, are used to map the presence of pipelines, utilities, underground storage tanks, and other subsurface obstructions. They can be used in both the vertical and horizontal dipole orientations. The horizontal dipole orientation is effective when exploring for steeply dipping features, and the vertical dipole is effective for more tabular features, such as mapping ground conductivities. Since the peak response for both system orientations is derived from materials at different depths in the subsurface and data from the inter-coil spacings are representative of various depths beneath the surface, a comparison of responses yields qualitative information on both near-surface and deeper subsurface conditions.

3.1.2.2 Magnetometry Equipment

Magnetometers, particularly the Geometrics G858g magnetic gradiometer, are ideally suited for detection and characterization of ferrous targets, such as the metal banding around the wooden pipes. Thus, magnetometers are the sensor of choice for many sites. They are usually preferable to EM sensors when the targets are ferrous; surface debris conditions are not significant; and where soil conductivities may be elevated and, thus, mask EM signatures. Magnetometers can also detect deeper ferrous material than other geophysical instruments.

3.1.2.3 GPR Equipment

GPR surveys will be conducted to further characterize source materials responsible for observed EM or MG anomalies. GPR depth of penetration is highly site specific and depends on the near-surface soil conductivity. Highly conductive soils, such as clays, can reduce signal penetration to less than 1 foot, whereas less conductive materials, such as poorly graded sands or limestone bedrock, may allow depth of penetration in excess of 50 feet.

Digital GPR data will be collected at the site using a GSSI SIR-2000, or equivalent, coupled to a 200- or 400-megahertz antenna. Initially, antenna selection will be dependent on site conditions and signal attenuation. The advantages of including GPR in the survey design are as follows:

- GPR data are useful in locating areas of disturbed soils.
- GPR data are useful in accurately locating and mapping nonmetallic structures (if present).
- GPR data are useful in estimating depths to the target.
- GPR data are useful in accurately mapping lateral boundaries of structures.

3.1.2.4 Global Positioning System

Because site conditions are favorable (no tree canopy and no large man-made structures), the single frequency Trimble PRO XRS GPS will be integrated with the geophysical sensors to provide continuous real-time navigational data. The availability of sufficient satellite coverage indicates that the use of global positioning system (GPS) is appropriate. Two factors dictate sufficiency of satellite coverage: 1) the view of the sky from the survey site, and 2) the number and height of GPS satellites above the survey site. The orbits of the GPS satellites are readily viewed through use of GPS planning software (Trimble SATVIZ™). By reviewing the satellite availability on a daily basis, optimal survey periods will be defined, and periods of poor satellite visibility will be coordinated with rest times, preventative maintenance, data downloading, and travel. Optimal survey period criteria occur when there are more than a minimum of four satellites, the precision dilution of position is less than five, and signal-to-noise ratio is greater than six.

3.2 Soil Investigations

Two types of soil samples will be collected as part of this investigation. First, soil samples will be collected from each of 30 test pit excavations (Section 3.2.1). After the test pit soil sample analytical results are received and reviewed, soil samples will be collected from each of 10 soil borings (Section 3.2.2). Table 2-2 summarizes the samples and analytical parameters, and Table 3-1 identified the specific sampling methods.

A qualified geologist or geotechnical engineer will be on site for all excavation, drilling, and sampling operations. The geologist/geotechnical engineer will perform logging and collect other information, as described in Section 3.2.3. All soil samples will be field screened using a field test kit for nitroaromatics (e.g., D-Tech® or equivalent). Also, any materials associated with the sewer lines that appear to be contaminated will be field screened. Although not expected, if raw explosive material is encountered during soil sampling, all activities will stop, and USACE will be contacted to discuss procedures for disposal of the raw explosive material.

3.2.1 Test Pit Excavations and Soil Samples

A total of 30 test pits will be dug with an excavator, perpendicular to the WWTP1 sewer lines throughout their length. These test pits will serve to confirm the location of the sewer lines as determined during the geophysical investigation (Section 3.1). Note that if the locations of the sewer line traces cannot be inferred from the results of the geophysical methods described in Section 3.1, an attempt will be made to find the sewer lines based on historical information, field observations, and aerial photographs. A review of current aerial photographs suggests linear scarring along the ground surface in the vicinities of these former lines. The test pits will also be used to provide access for sampling soils underlying the sewer lines. Condition, composition, and size of the sewer lines will also be noted. Potential locations of the 30 test pits are shown on Figure 3-1; actual locations may be influenced by geophysical survey results and field conditions.

One soil sample will be collected from immediately below the sewer line in each test pit. The samples will be collected either with the excavator bucket or by hand auger. Each of these 30 samples (and 3 duplicates) will be analyzed only for nitroaromatics, using EPA Method SW-846

8330. The analytical results of these samples will be used to determine if waste materials previously transported by the WWTP1 sewer lines had leaked and impacted adjacent soil. To expedite the schedule, these samples will be analyzed on a 7-day turnaround.

3.2.2 Direct-Push Soil Samples

A total of 10 direct-push borings will be advanced immediately along the WWTP1 sewer lines. The locations of these borings will be based on the analytical results of the test pit soil samples and field observations. Two soil samples will be collected from each boring: one from 0 to 1 foot bgs and one from the approximate depth of the bottom of the sewer line to a depth of 2 feet below this level, unless field observations suggest that this sample should be adjusted to a more shallow depth. If such an adjustment were made, the justification would be noted on the FADL and sample collection log.

The 20 soil samples (and 2 duplicates) will be analyzed for nitroaromatics, SVOCs, PCBs, and target analyte list metals. One surface soil sample will also be analyzed for total organic carbon to provide information for modeling if needed. The analytical results of the deeper direct-push soil samples will be used in conjunction with the results of the test pit samples to determine whether materials previously transported via the WWTP1 sewer lines have impacted adjacent soils. The analytical results of the surface soil samples will be used to determine if any leakage from the WWTP1 sewer lines have impacted the associated surface soil such that exposure may result in potential human health and/or ecological effects. These direct-push soil samples will be collected using the procedures described in Section 3.2.3.

3.2.3 Soil Sampling Procedures

A qualified geologist or geotechnical engineer will be on site for all drilling and sampling operations. The geologist/geotechnical engineer will visually classify and log all borehole material according to the Unified Soil Classification System and EM 1110-1-4000 (USACE, 1998) on the hazardous, toxic, and radiological waste drilling log (Figure 4-2 of the SWSAP).

Soil samples collected for chemical analysis will be documented by sample collection logs and analysis request/chain-of-custody record forms (Figures 4-7 and 6-2 of the SWSAP [Shaw, 2008a]), following field custody procedures specified in Section 5.1 of the QAPP (Shaw, 2008b). Any changes from this SSAP or the SWSAP will be recorded in chronological order in the variance log shown on Figure 9-1 of the SWSAP (Shaw, 2008a). All direct-push soil samples collected by Shaw field personnel will be documented through the use of drilling borelogs (USACE Eng. Forms 5056-R and 5056A-R).

Continuous logging performed by the geologist/geotechnical engineer will include detailed subsurface information from examining drill cuttings, recording samples/cores, and noting first-encountered and static groundwater levels for each borehole. Soil overburden material will be sampled continuously for the purposes of visual classification of the borehole material, but samples will not be saved for geotechnical analysis. Daily field notes will be kept on a FADL and will include sufficient information to reconstruct the progress of excavation, drilling operations, problems encountered, temporary piezometer installation procedures (Section 3.3.3), etc. After completion of database entry, all field forms and documents will be archived in the project files at the Shaw office in Knoxville, Tennessee. A copy of borelogs and well construction logs will be included in an appendix to the final RI report.

For soil intervals that are collected for analytical sample analysis, the samples will be collected in the appropriate jars prior to lithologic logging. If additional sample volume is required for the analysis, QA/QC requirements, or other purposes, the soil will be placed into a decontaminated stainless-steel bowl or new, gallon-size resealable plastic bag. In the case of direct-push samples, a second boring will be completed immediately adjacent to the original location. The surface soil sample (0 to 1-foot interval) from the adjacent boring will be combined with the original surface soil sample, homogenized, and transferred to appropriate sample jars. Upon filling a sample container, the jar will be placed on ice and the proper paperwork completed.

As mentioned in Section 3.2.2, borings will be advanced and soil samples will be collected using direct-push drilling technology. The direct-push unit uses a hydraulically powered percussion hammer to drive a decontaminated soil sampling device with retractable tip (point) to a required depth. Soil samples for chemical analysis will be handled and packaged as described in Chapter 5.0. All direct-push sampling equipment that will come in contact with the samples will be decontaminated prior to use and between each sample collected, in accordance with Section 4.3. Once the subsurface soil sample is collected, selected borings will be advanced to bedrock (or refusal) and a piezometer will be installed, as described in Section 3.3.3. Continuous logging will be performed to the bottom of the borehole.

Soil borings in which a piezometer are not installed will be abandoned at the completion of soil sampling and piezometer installation activities. The abandonment will be performed in accordance with Ohio Department of Natural Resources (ODNR) requirements, following Ohio Environmental Protection Agency (OEPA) (2005) guidance. A well sealing report will be submitted to ODNR. The boreholes will be abandoned by pressure grouting with neat cement from the bottom to the top of the borehole using a tremie pipe. The neat cement mixture used to seal the borehole will be composed of a ratio of one 94-pound bag of portland cement to no more than 6 gallons of water and 2 to 8 percent bentonite powder.

At the completion of the direct-push soil sampling event piezometer installation (Section 3.3.3), the remaining soil from the boring will be drummed. A composite soil sample of this drummed material will be analyzed for chemical parameters for disposal characterization, as described in Chapter 6.0.

3.3 Groundwater Investigations

Groundwater will be investigated in a phased approach. First, groundwater will be collected from each of 10 piezometers installed along the WWTP1 sewer lines within the overburden/shale unit. Based on the analytical results and groundwater flow patterns of the piezometer samples, three monitoring wells will be installed in the overburden/shale and three monitoring wells will be installed in the underlying limestone formation. Each piezometer and monitoring well will be sampled using a low-flow technique described in Section 3.3.7, unless the Ohio Environmental Protection Agency (OEPA) and USACE approve a variation. Table 2-2 summarizes the samples and analytical parameters, and Table 3-1 identifies the specific sampling methods.

If bedrock (or refusal) is encountered at less than 5 feet and the borehole is dry, then no piezometer or well will be installed at this location, as it is unlikely to produce measurable water. In this case, a suitable alternate location will be sought. In addition, previous investigations have shown a strong seasonal and topographic variation in water levels in the overburden at PBOW which can result in dry boreholes. The water levels in the piezometers will be measured a minimum of 24 hours after installation of the last piezometer and periodically over the course of the field effort for this site. Water level measurements in the piezometers will be taken to the nearest 0.01 foot.

3.3.1 Piezometer Samples

A piezometer will be installed at each of the 10 soil boring locations described in Section 3.2.2. Once soil sampling is complete to the bottom of the sewer line and the associated soil sample is collected (Section 3.2.2), the boring will be advanced to bedrock (or refusal). As described in Section 3.2.3, the boring will be continuously logged, with lithologic and hydrologic observations appropriately recorded. Piezometer installation is described in Section 3.3.3. Each piezometer water sample will be collected using a low-flow technique and analyzed only for nitroaromatics. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. The piezometer sample results will be used to aid in determining the appropriate locations of monitoring wells to be installed in the two groundwater zones (i.e., overburden/shale and underlying limestone). To expedite the schedule, these samples will be analyzed on a 7-day turnaround.

3.3.2 Monitoring Well Samples

A total of six wells will be installed along or adjacent to the WWTP1 sewer lines, unless based on the results of the piezometer samples and other site observations, the project delivery team makes the determination that one or more of these wells are unnecessary. Three of these six monitoring wells will be installed in the overburden/shale and the other three wells will be installed in the limestone water-bearing zone. The specific location of each well will be determined by the geologist/geotechnical engineer based on the analytical results of the piezometer samples. Monitoring well installation and development are described in Section 3.3.4.

Each monitoring well sample will be sampled using a low-flow technique (Section 3.3.7) and analyzed for volatile organic compounds, SVOCs, nitroaromatics, PCBs, dissolved (filtered) metals, total (unfiltered) metals, and water quality parameters. Also, ferrous iron will be analyzed in the field using Hach test kits. Two rounds of samples will be collected from each well at different times of the year (e.g., spring and fall) to allow for seasonal differences. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. In addition, the condition of all surface components of the monitoring wells sampled will be documented with the recommendation for repair. The surface components will include the concrete pad, protective posts, protective casing, and well casing. In addition, the condition of the well locks and lock hasps will be documented.

3.3.3 Piezometer Installation

Temporary piezometers are typically used to measure static water levels and collect groundwater quality samples in commonly slow recharging environments. The WWTP1 sewer lines piezometers will be made of new 1-inch outside diameter polyvinyl chloride (PVC) material and placed into the borehole through the direct-push tooling prior to removal or inserted into the borehole after the tooling is removed. These will be advanced to bedrock (or refusal), and continuous lithologic logging will be performed. The piezometer will be constructed with 5 to 10 feet of PVC screen (0.010 slot) and PVC casing. No filter pack material will be placed around the well screen. Because the sampling will occur reasonably quickly after the piezometers have been installed, semi-permanent seals are not necessary. The top 1 to 2 feet of the borehole will be sealed with bentonite to prevent precipitation water or surface runoff from infiltrating the borehole. If sealing with bentonite proves difficult, a plastic surface seal may be used around the borehole and covered with additional soil or bentonite sloping away from the piezometer to promote runoff and prevent any surface water from entering the borehole. Figure 4-5 of the SWSAP shows a typical piezometer construction form that will be completed for all piezometers. Upon an adequate water column in the piezometer to permit sample collection (i.e., greater than 24 inches), groundwater sampling will be conducted as described in Section 3.3.7

Following the groundwater level measurement associated with the first round of monitoring well sampling (Section 3.3.2) and permission from USACE, the PVC materials will be removed from all temporary piezometers boreholes. The boreholes will be abandoned in accordance with OEPA and ODNR codes, regulations, and guidance, including the following: Ohio Administrative Code 3745-9-10, *Abandoned Well Sealing*; OEPA (2005) technical guidance on sealing abandoned monitoring wells and boreholes; and Ohio Revised Code Section 1521.05, *Well Construction and Sealing Log*. Pressure grouting from the bottom to the top of the borehole with a tremie pipe will be used to seal the wells. After 24 hours, the borehole will be checked for settlement and additional grout added, if necessary. Neat cement grout, which uses a ratio of one 94-pound bag of portland cement to no more than 6 gallons of water and 2 to 8 percent bentonite powder, will be used as the sealant. Piezometer material (PVC screen and casing) will be cleaned, cut into 5-foot manageable lengths, and discarded into the local sanitary trash.

3.3.4 Monitoring Well Installation and Development

3.3.4.1 Monitoring Well Installation

The geologist/geotechnical engineer will schedule and coordinate the locating of all underground utilities in the vicinity of the borehole site prior to drilling activities. The geologist/geotechnical engineer will assume one mobilization for activities related to installation of the six new monitoring wells.

The estimated depth for each of the three new overburden/shale wells is 20 feet, and the estimated depth for each of the three new limestone monitoring wells is 80 feet. The target depths of each new well are estimated based on well construction information from existing wells in the area. Actual installation depths will be adjusted in the field as necessary for collection of appropriate groundwater samples.

A qualified geologist/geotechnical engineer will be on site for all drilling, installation, development, and testing operations. Well installation and drilling methods will be in accordance with the procedures and requirements described in EM 1110-1-4000, *Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites*, and applicable state regulations and requirements, including Ohio Administrative Code 3575-9-03, *Monitoring*

Well. Limestone wells are anticipated to be installed using "double casing" as described in Section 3-10 of EM 1110-1-4000 to install a well through a contaminated upper zone (USACE, 1998). A well log will be completed and filed on line with ODNR (http://www.dnr.state.oh.us/water/maptechs/submitlogs/).

Soil and rock core logging will be continuous for the entire drilling procedure during the monitoring well installation. The geologist/geotechnical engineer will visually classify and log all borehole material according to the unified soil classification system (USCS) and EM 1110-1-4000 (USACE, 1998). Soil overburden material will be sampled continuously for the purposes of visual classification of the borehole material, but samples will not be saved for geotechnical analysis. Soil boring samples collected during well installation processes will not be analyzed for chemical parameters, except for disposal characterization as described in Chapter 6.0.

Three overburden/shale and three limestone bedrock monitoring wells will be installed at each AOC. Borings for overburden/shale monitoring wells will be advanced 7 to 8 feet past the depth at which groundwater is encountered or until bedrock is encountered using hollow-stem auger drilling methods or other appropriate drilling methods. Two-inch inside diameter polyvinyl chloride (PVC) well material consisting of a 10-foot length screen and riser will be installed into the borehole. A filter pack will be tremied into the borehole to surround the screen and brought to a height of approximately 2 feet above the screen top. An approximate 2 to 5-foot bentonite seal will be tremied to depth above the filter pack followed with a neat cement/bentonite mixture (95 percent Type II or V portland cement and 5 percent bentonite powder mixed with 5 to 7 gallons clean water) to approximately 3 feet below grade.

Limestone bedrock borings will drill bedrock using a rock core bit cutting a maximum 6-inch outside diameter (OD) borehole and a rock core tube 5 feet in length. If a 6-inch OD rock bit is not used during bedrock drilling, after reaching the desired depth for monitoring well installation, the borehole will be reamed with a rotary bit to attain a 6-inch OD diameter borehole. This will allow a total of 4 inches of filter pack material to surround the 2-inch-diameter screen placed in the borehole for the monitoring well. Upon removal of the rock core tube, measurement of the rock recovered compared to the run length (length of the bedrock drilled) will be made. If the rock core length does not match the run length, total depth of the borehole will be measured to determine if the rock core was lost or washed way. Mention of the lost core on the borelog will be made. Fractures (mechanical, natural, or healed) will also be included on the borelog.

After a lithologic interpretation of the rock core is completed, the bedrock core will be placed into a wooden or cardboard core box and photographed with a digital camera. Prior to photographing, the rock core will be sprayed with water to help distinguish the features of the rock core (color, fracturing, etc.). The top of the core run should be in the upper left of the photograph and the bottom of the core in the lower right corner of the photograph. A scale (i.e. rock hammer, note book, tape measure, etc.) will be included in the photograph for distance approximation.

Construction of the limestone bedrock wells will follow the same requirements as the overburden/shale wells. Requirements are listed in USACE (1998). Typical monitoring well installation and construction diagrams are included in the SWSAP (Shaw, 2008b). All monitoring well drill cuttings will be drummed, labeled, and handled as described in Chapter 6.0

3.3.4.2 Monitoring Well Development

Each monitoring well will be developed using a submersible pump, peristaltic pump with Teflon® tubing, or bailer as soon as practical, but no sooner than 48 hours nor longer than 7 calendar days after the placement of the internal mortar collar around the well. Prior to development, the static water level will be measured from the top of the casing and recorded. Static water levels will also be measured 24 hours after development. The well will be developed until discharging water is clear to the unaided eye and the sediment thickness remaining in the well is less than 5 percent of the screen length. If yields permit, the standing water volume in the well (calculated as the volume of water in the well screen and casing and saturated annulus) will be removed at least five times. In addition, if water is used during bedrock drilling, any volume lost will be recorded and five times the amount will be removed during development. For each well, a sample of the last water removed during development will be captured and retained for visual inspection and photographing. During development, field measurements of pH, specific conductance, and temperature will be made, and descriptions of the development technique and the physical characteristics of the water (clarity, color, turbidity, and odor) will be recorded by the geologist/ geotechnical engineer. Wells will be developed by pumping, bailing, and surging without using acids, flocculants, disinfectants, or dispersing agents. All purged water will be drummed at the well site. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well. The development procedure will continue until the following conditions are met:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- Thickness of the accumulated sediment in the well is less than 1 percent of the length of the well screen.
- Temperature, pH, specific conductance values stabilize.
- Three consecutive turbidity readings are less than 100 nephelometric turbidity units (NTU).
- A volume of water has been removed equal to five times standing water in the well, including the well casing and screen, and the saturated annular space assuming 30 percent porosity.

Water will not be added to the well once the well has been grouted and sealed. If heavy or caked sediments must be removed by washing, the water will be from a potable water source and a sample will be submitted for analysis.

If the groundwater is not clear and free of sand after four hours of well development, Shaw field personnel and the Shaw project geologist will develop a plan for proceeding, and will discuss this plan with USACE. After final development of each well, approximately 1 liter of water from the well will be collected in a clear glass jar, labeled, and photographed in color with a quality digital or 35-millimeter camera. The photograph will be submitted as part of the well development log. The photograph will be a suitably back-lit close-up to show the clarity of the water. The development water sample will be archived until receipt of photographs. The well will not be sampled for a minimum of 14 days after development.

The following records will be kept in a well development log:

- Project name and location
- Well designation and location
- Date and time of well installation
- Date and time of well development
- Static water level from top of well casing before well development and 24 hours after well development
- Quantity of fluid in well prior to development:

- Standing in well
- Contained in saturated annulus, based on an assumed 30 percent porosity

- Field measurements of pH, conductivity, and temperature before, twice during, and after development at a minimum and until these values stabilize
- Field measurement of turbidity (NTU) until three consecutive measurements are less than 100 NTUs
- Depth from top of well casing to bottom of well
- Screen length
- Depth from top of well casing to top of sediment inside well, before and after development
- Physical character of removed water, including changes in clarity, color, particulate, and odor
- Type and size/capacity of pump and/or bailer used
- Description of surge technique
- Measured height of well casing above ground surface at time of development
- Typical pumping rate and estimated well yield
- Quantity of water/fluid removed during development, both incremental and total
- Disposal of development water.

3.3.5 Water Level Monitoring

After the WWTP1 sewer line piezometers have been installed for a minimum of 24 hours (and prior to groundwater sampling), groundwater levels will be measured and recorded for all 10 piezometers. Water elevation measurements will also be recorded for each piezometer immediately prior to sampling. The depth to water will be measured to the nearest 0.01 foot from the top of the PVC riser at the point which was marked during surveying (Section 3.0).

The water elevations of all six monitoring wells will be measured at once, prior to purging the first well (see Section 3.3.7). The water levels of the 10 piezometers will also be taken at this time during the first monitoring well sampling event. This is done to provide more complete information concerning groundwater flow in the vicinity of the WWTP1 sewer lines. The depth to water will be measured to the nearest 0.01 foot from the northern edge of the riser (inner casing) which was marked during surveying. Note that the piezometers will be abandoned after this measurement, as described in Section 3.3.3. Therefore, the water levels of only the six monitoring wells will be measured as part of the second monitoring well sampling event.

3.3.6 Groundwater Sampling Equipment

The equipment required for groundwater sampling includes:

- Water level indicator
- Low-flow submersible pump or peristaltic pump with Teflon-lined tubing
- Oxygen-reduction potential (Eh), dissolved oxygen, pH, temperature, turbidity, and specific conductance meters
- Appropriate sample bottles and temperature-controlled container
- Plastic sheeting
- Five-gallon buckets with lids
- Photoionization detector (PID)/lower explosive limit (LEL) meter
- Mason jar for calculating purge rate
- Well construction diagrams.

If because of low water yield the well cannot be sampled using a low-flow technique, the following equipment will be required:

- Nylon rope
- Teflon, PVC, or stainless-steel bailer of appropriate size for the monitoring well fitted with a bottom-emptying device.

3.3.7 Groundwater Sampling Methodology and Procedures

Piezometers will be sampled approximately 24 hours after installation in conjunction with the water level measurements. A water level will be recorded for all piezometers, just prior to the piezometer sampling event (Section 3.3.2). The monitoring wells will be purged and sampled a minimum of 14 days after development (Section 3.3.5), unless a variance is agreed to by the USACE. Immediately prior to the first round of monitoring well groundwater sampling, the water levels of all piezometers and monitoring wells involved in this investigation will be measured. This will allow for more accurate groundwater flow mapping and flow direction determination. Before a sample is collected from each well, the water level will be measured again. This same protocol will be followed immediately prior to the second round of monitoring well sampling, except that the piezometers will have been removed (Section 3.3.3).

Two procedures are available for purging and sampling wells and piezometers: low-flow (minimal drawdown) and bailing. Low-flow is the preferred purging method where adequate recharge exists. If wells or piezometers do not recharge adequately to use low-flow sampling, bailing will be used depending on the static water level relative to the screened interval. Both of these methods are described in the following procedures:

- The well or piezometer will be checked for proper identification and structural integrity.

- After unlocking the well or piezometer and removing the cap, a PID/LEL meter will be used to measure the concentration of organic vapors and hydrogen sulfide at the top of casing and in the breathing zone. If readings are above background, safety precautions outlined in the SWSHP will be followed.

- The depth to water will be measured using a decontaminated water level indicator. Then the volume of water in the casing and screen and annular volume will be calculated.

- Where recharge rates permit, the well or piezometer will be purged and sampled using a modified low-flow (minimal drawdown) sampling methodology. Either a submersible pump (e.g., bladder pump, inertial pump), or peristaltic pump with Teflon tubing will be used to complete the sampling. The pump (or tubing) will be inserted into the midportion of the screened interval or suspected water producing interval and operated at a rate that minimizes drawdown. Typically, purging rates are on the order of 200 milliliters per minute (mL/min) to 500 mL/min. The purge rate will be set such that drawdown is never greater than 0.5 feet (6 inches), if possible. If drawdown is greater than 0.5 feet, it is critical that stability of the water level is reached and maintained, above the screened interval. Water chemistry parameters (pH, Eh, conductivity, temperature, dissolved oxygen and turbidity) will be monitored to confirm stability.

- If the pre-pumping (static) water level is above the top of the screened interval and drawdown exceeds 0.5 feet even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, iterative pumping and recovery cycles will be required to remove at least one volume of the standing water in the casing and annular space. In this instance, the water level must not be allowed to drop below the top of the screened interval. It is, however, acceptable to pump out the stagnant water in the casing at a higher purge rate but pumping must be stopped when the water level reaches the top of the screened interval. Once at least one volume is removed, the well or piezometer may be sampled. It should be noted, however, that attempts will be made to remove more than one volume of water.

- If the pre-pumping (static) water level is below the top of the screened interval and drawdown exceeds 0.5 feet even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, iterative pumping and recovery cycles will be required to remove at least one volume of the standing water in the casing and annular space. However, in some wells, recharge may be so low that adequate purging may not be achieved even over a period of days. In this case, the well or piezometer may be sampled without purging, after consultation with the USACE.

- During purging, field measurement of pH, Eh, temperature, turbidity, dissolved oxygen, and conductivity will be performed. When using low-flow sampling, once these parameters are stable, samples can be collected. If stability is not achieved after 4 hours of purging, Shaw will notify the USACE and discuss a plan for sampling the well or piezometer. Stability is defined as follows:

  - pH +/- 0.1 standard units
  - Eh +/- 10 millivolts
  - Temperature +/- 3% degrees Celsius (°C)
  - Turbidity (three consecutive readings less than 100 NTUs)
  - Dissolved oxygen +/-1%
  - Conductivity +/-3% of reading.

- Where possible, groundwater samples will be collected using a submersible sampling pump or peristaltic pump and in-line sampling. Where the use of in-line sampling is not possible, a bottom-emptying Teflon bailer will be used.

- Samples for groundwater analytes will be collected in the following order: 1) nitroaromatics; 2) SVOCs; 3) dissolved metals; 4) total metals; 5) turbidity; alkalinity, total dissolved solids, total suspended solids, chloride; and sulfate; 6) nitrate; 7) cyanide; 8) hardness; and 9) ferrous iron.

- Sample containers will be labeled with appropriate identifying information (location, date, time, condition, added preservatives, sample crew, and requested analysis). Preprinted labels will be provided by the field sampling crew leader. Each sample will be logged in a field notebook at the time of collection. Sample containers of appropriate volume and composition will be prepared in advance to ensure the collection of sufficient volumes for all specified analyses.

- The samples will be collected so as to minimize aeration as water enters the bottle. Pumping rates will not exceed 500 mL/min. Samples collected for nitroaromatic analysis will be collected first.

- Samples for metals analysis will be collected in two separate containers; one will be filtered and the other unfiltered. Filtered samples will be collected during groundwater sample collection using a disposable, inline 0.45-micron filter attached to the discharge tubing. The filter will be disposed after groundwater sample collection from each sample point.

- All filled sample containers will be transferred to a cooler chest (kept at 4 degrees ^{0}C) and delivered to the laboratory in sufficient time so that specified holding times are not exceeded. Details of the sample preservation, packing, and shipping are provided in Chapter 7.0.

In addition to the primary water samples, certain field quality control samples will be prepared as described in succeeding paragraphs. The geologist/geotechnical engineer will coordinate with the primary and QA laboratories as to the volumes of sample necessary to satisfy all internal laboratory QC requirements. All samples will be collected and analyzed in conformance with applicable EPA and USACE requirements, using techniques and equipment described herein and in the SWSAP (Shaw, 2008a).

3.4 Land Surveying

Following completion of confirmation soil sampling and piezometer/monitoring well installation, Shaw will secure the services of an Ohio-registered professional land surveyor to determine the coordinates and elevations of confirmation soil borings and monitoring well locations. The horizontal coordinates will be to the closest 0.1 foot and referenced to the State Plane Coordinate System. Vertical coordinates (ground elevation and well riser, if applicable) will be to the nearest 0.01 foot and referenced to the 1929 National Geodetic Vertical Datum. If the 1929 Datum is not readily available, the existing local vertical datum will be used. All survey data will be tabulated. Loop closure for survey accuracy will be within the horizontal and vertical limits given above. Once sample survey information is available, it will be entered on approved Shaw boring logs.

3.5 Utility Clearances

Prior to beginning any intrusive investigation (i.e., soil boring, temporary piezometer installation), to fulfill Shaw standard operating procedures and USACE requirements, all sites will be marked for underground utilities by personnel from NASA, Plum Brook Station Health and Safety Division, or other appropriate department. Even after NASA has located underground utilities that may be present in the AOC, all direct-push locations will be hand dug, probed with an air knife, or screened with geophysical instrumentation to a depth of 5 feet before drilling begins.

3.6 Site Access

All Shaw personnel and subcontractors will meet each morning at the NASA Plum Brook Station for the morning tailgate safety meeting, equipment calibration, gathering of needed material, and replenishing of water. At the end of each day, IDW generated during fieldwork will also be moved by the subcontractor back onto the Shaw IDW storage area located in the secured NASA staging area. Therefore, all Shaw personnel and any subcontracted personnel involved must be U.S. citizens. Names of Shaw personnel and Shaw subcontractors will be provided by Shaw to Mr. Robert Lallier, NASA Environmental Coordinator, at least 72 hours in advance so that site access can be arranged. All personnel entering the site will be appropriately trained and instructed by Plum Brook Station concerning site safety issues.

3.7 Abandonment

After the initial sampling of any monitoring well, if characteristics are similar to former monitor well BED-MW27 (off-gassing of hydrogen sulfide), abandonment may be conducted if requested by USACE. Well abandonment procedures will follow the USACE guidelines and will be in accordance with OEPA and ODNR codes, regulations, and guidance, including the following: Ohio Administrative Code 3745-9-10, *Abandoned Well Sealing*; OEPA (2005) technical guidance on sealing abandoned monitoring wells and boreholes; and Ohio Revised Code Section 1521.05, *Well Construction and Sealing Log*. Well sealing reports will be submitted to the ODNR Division of Water. Abandonment will be performed as follows:

- Groundwater will be bailed or pumped from the monitoring well, contained, and disposed of as IDW.

- Removal of well material will be attempted. If the well isolation casing and PVC well casing and screen can be removed, it will be cut into approximately 5-foot lengths and decontaminated using the approach described in Section 5.1 of the SWSAP. Surface completion material (guard posts, pad, protective steel casing) will be removed.

- If removal of the isolation casing and the well screen/casing is not possible, abandonment in place will be conducted. Steel isolation casing and PVC well material will be cut approximately 3 feet bgs.

- A neat cement grout will be tremied from the bottom of the well screen until undiluted grout flows from the borehole/well at the ground surface to seal the borehole. The grout will be in the ratio of one 94-pound bag of portland cement to no more than 6 gallons of water and 2 to 8 percent bentonite powder.

- After 24 hours, the borehole/well will be checked for settlement and additional grout added, if necessary. A tremie pipe will be used again if the depth of the unfilled portion of the borehole is more than 15 feet.

- Ground surface should be restored as originally found, which may include reseeding with grass seed and straw, repairing asphalt, or repairing concrete.

4.0 Sample Analysis and Decontamination Procedures

4.1 Sample Number System

Sample numbering system to be used during this investigation will conform to the USACE Nashville District's numbering convention. Specifically, each sample will be assigned a unique sample identification number that describes where the sample was collected. Each number consists of a group of letters and numbers, separated by hyphens. The sample media and numbering system are described as follows.

Project Code	Year	Sample Type[a]	Site Identification[b]	Location (Well ID)	Sample Number	Depth[c]
PBOW	08	XX	XXXX	XXXX	XXXX	(XXXX)

[a]Sample type:

SS – surface soil sample
SB – subsurface soil sample
GW – groundwater sample
MS – matrix spike
MD – matrix spike duplicate

[b]Site:

WWSL1 – Waste water Treatment Plant 1 sewer lines (Note that the acronym is changed from that which appears in the rest of this SSAP to avoid possible confusion of the samples with those collected for Waste water Treatment Plant 1, which is being investigated separately.)

[c]Depth: Only required for soil samples.

The complete sample number will be recorded by the Shaw field geologist/geotechnical engineer in the FADL and/or in the boring log, and in the sample collection log as appropriate.

4.2 Analytical Program

The analytical program has been designed to acquire sufficient and defensible data to determine the extent of contamination in the investigated areas. Table 3-1 summarizes the analytical parameters required and associated laboratory methods to be used during this investigation.

A contract laboratory will analyze samples for nitroaromatics by EPA Method SW-846 8330. All applicable analyses will meet the recommended method guidance found in *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition Update (EPA, 1996) and its subsequent updates. They will meet the QA/QC requirements outlined in the EM-200-1-6 *Chemical Quality Assurance for Hazardous, Toxic and Radioactive Waste (HTRW) Projects* (USACE, 1997). The analytical laboratory must comply with *Quality Systems Manual for Environmental Laboratories, Final Version 3* (DOD, 2006). All other requested analyses must conform to their specified method(s).

4.3 Decontamination Procedures

Decontamination requirements and procedures are specified in detail in Chapter 5.0 of the SWSAP (Shaw, 2008a) and will be followed during the current RI. The Shaw field coordinator must contact Plum Brook Station for access to a potable water source for decontamination use. The following summarizes decontamination procedures for equipment before site entry, between borings, and before site departure:

Nonsampling equipment (direct-push rods, augers, drill rods, etc., that does not contact analytical samples):

- Steam-rinse with potable water, or wash and scrub using a brush with nonphosphate detergent and then rinse with potable water.

Equipment that may come in contact with samples for chemical analysis (stainless-steel homogenization bowls, mixing spoons, drill bit shoes, drill sleeves, etc.):

- Wash and scrub using a brush with nonphosphate detergent.
- Rinse with potable water.
- Rinse with American Society for Testing and Materials (ASTM) Type II water.
- Rinse with isopropanol (when sampling for metals).
- Rinse with 10 percent nitric acid (for glass and Teflon sampling equipment).
- Rinse with ASTM Type II water.
- Rinse with hexane (when sampling for PCBs).
- Final rinse with ASTM Type II water; the volume of water used will be at least five times greater than the volume of hexane used.
- Air dry.
- Wrap in aluminum foil.

Decontamination wash water and rinse water will be managed for disposal as described in Section 6.2

5.0 Sample Preservation, Packing, and Shipping

Sample containers and caps will be new, certified as pre-cleaned, and made of materials recommended by the EPA in Title 40, Code of Federal Regulations, Part 136 and SW-846 (EPA, 1996 [3rd Edition, Update III]). Sample containers and preservatives/preservation methods are summarized in Table 5-1. Sample containers will be supplied and shipped to the job site by the designated primary laboratory.

Each sample container will be bagged before placement in the cooler. Sample holding times will be calculated from the date the sample is collected.

Samples for chemical analysis will be placed in coolers as soon as possible after collection and will be packed to minimize container breakage by using vermiculite, Styrofoam peanuts, or bubble wrap to fill void spaces in the cooler. Coolers will be taped, marked, and sealed, and custody will be maintained, as described in Chapter 6.0 of the SWSAP. Samples will be cooled to a temperature of approximately 4°C and maintained at that temperature by means of double-bagged ice until the cooler is received at the laboratory. Coolers will be shipped to the laboratory by a next-day delivery service. The temperature of each cooler will be taken with an infrared thermometer upon receipt. Notification of shipment, including air bill number, will be telephoned or faxed to the laboratory on the day of sample collection. If this is not possible, the laboratory will be notified the following morning.

Completed analytical request/chain-of-custody records will be secured and included with each shipment of coolers to:

ATTN: Melania Harris
Analytical Management Labs, Inc.
15130 South Keeler
Olathe, Kansas 66062
P:913-829-0101 ext.23
F:913-829-1181
mharris@amlabinc.com

6.0 Investigation-Derived Waste Management Plan

Anticipated IDW during field activities includes soil (drill cuttings), purge/development water, decontamination fluid, and disposable personal protective equipment (PPE). Detailed procedures for IDW management are provided in Chapter 8.0 of the SWSAP (Shaw, 2008a). The following is a brief summary of the procedures for handling IDW.

6.1 Soil and Groundwater

Residual subsurface soil will be placed in 55-gallon drums upon completion of field sampling. IDW drums will be labeled to indicate project name and date collected.

6.2 Decontamination Fluid

Limited quantities of decontamination fluid, including wash water, nonphosphate soapy water, and final rinse water will be kept in plastic tubs during the decontamination process and will be placed in 55-gallon drums upon completion of field sampling. Decontamination fluid containing small quantities of solvents such as isopropanol, methanol, and hexane will be collected in metal pans for evaporation.

6.3 Sampling Equipment and Personal Protective Equipment

Limited quantities of PPE and sampling equipment, including Tyvek suits, latex/nitrile gloves, plastic, and disposable tubing used for groundwater sampling, will be generated during sampling. All sampling equipment and PPE will be double-bagged and disposed of in on-site dumpsters. If any of the sampling equipment and PPE appears to be grossly contaminated, it will be decontaminated prior to disposal.

6.4 Investigation-Derived Waste Sampling

All soil and water IDW will be sampled at the completion of field work. Table 3-1 summarizes the analytical parameters and methods for the IDW samples. For soils, one composite soil sample will be collected from drummed soil for each AOC. The composite sample will then be submitted to the identified laboratory for a full toxicity characteristic leaching procedure analysis and nitroaromatics. Seven-day turnaround time will be used, unless otherwise directed by the project manager.

When the analytical results are received, Shaw personnel will evaluate the results and make a determination of off-site disposal methods. Possible disposal facilities will be identified by

Shaw; however, selection of the facility or facilities to receive the IDW will be the responsibility of USACE.

7.0 References

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TABLES

Table 2-1

Summary of Data Quality Objectives
Waste Water Treatment Plant No. 1 Sewer Lines
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Potential Data Users	Available Data	Conceptual Model	Media of Concern	Data Uses and Objectives	Data Types	Analytical Level
EPA	Previous environmental investigations show	Contaminant Source Production of TNT, DNT,	Groundwater	Define site physical features and characteristics	Groundwater Nitroaromatic explosives Volatiles	Definitive Screening Level
OEPA	varying degrees of contamination in the	and pentolite. Past DOD operations.	Soil	Determine nature and extent of DOD-related contamination in soil and groundwater along the sewer lines	Semivolatiles Polychlorinated biphenyls	
DOD	groundwater and soil.	Migration Pathways		Determine chemical characteristics of contamination	Metals Water quality parameters	
USACE		Leaking of materials in sewerlines to soil and		Evaluate fate and transport of contamination		
NASA		groundwater. Leaching from soil to groundwater.		Determine if overburden groundwater underlying the AOCs is sufficient in volume	Soil Nitroaromatic explosives	
Shaw				and quality to be defined as a potential drinking water source in the State of Ohio	Semivolatiles Polychlorinated biphenyls	
Other Contractors		Potential Contaminants of Concern		Obtain site data of quality, quantity and distribution appropriate for site	Metals Total organic carbon	
Possible Future Land Users		Explosives		Obtain site data of quality, quantity and distribution appropriate for site characterization, risk assessment, and feasibility study.		

DOD - U.S. Department of Defense.
EPA - U.S. Environmental Protection Agency.
OEPA - Ohio Environmental Protection Agency.
USACE - U.S. Army Corps of Engineers
NASA - National Aeronautics and Space Administration.
Shaw - Shaw Environmental, Inc.

Table 2-2

Summary of Groundwater and Soil Analytical Samples
Waste Water Treatment Plant No. 1 Sewer Lines
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Test Pit Soil Samples						
Parameters	Field samples	QA/QC Samples	Rinsates	Source Water	Trip Blanks	Matrix Spike/Duplicates
Nitroaromatics	50	5	5	1	NA	5/5
Direct-Push Soil Samples						
Parameters	Field samples	QA/QC Samples	Rinsates	Source Water	Trip Blanks	Matrix Spike/Duplicates
Nitroaromatics	20	2	2	1	NA	2/2
TCL SVOCs	20	2	2	1	NA	2/2
PCBs	20	2	2	1	NA	2/2
TAL Metals	20	2	2	1	NA	2/2
Total Organic Carbon	1	NA	NA	NA	NA	NA
Piezometer Samples						
Parameters	Field samples	QA/QC Samples	Rinsates	Source Water	Trip Blanks	Matrix Spike/Duplicates
Nitroaromatics	10	2	2	NA	NA	2
Monitoring Well Samples [a]						
Parameters	Field samples	QA/QC Samples	Rinsates	Source Water	Trip Blanks	Matrix Spike/Duplicates
Nitroaromatics	12	2	2	2	NA	2
TCL VOCs	12	2	2	2	2	2
TCL SVOCs	12	2	2	2	NA	2
PCBs	12	2	2	2	NA	2
TAL Metals, Total	12	2	2	2	NA	2
TAL Metals, Dissolved	12	NA	NA	NA	NA	NA
Water Quality Parameters [b]	12	NA	NA	NA	NA	NA

TCL - Target compound list; VOC - Volatile organic compound; SVOC - semivolatile organic compound; TAL - target analyte list

PCB - polychlorinated biphenyl

[a] Quantities are based on two rounds of sampling.

[b] Refer to Table 4-1 (footnote "c") for identification of groundwater quality parameters.

Table 3-1

Summary of Analytical Parameters and Methods
Waste Water Treatment Plant No. 1 Sewer Lines
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters	Analytical Method[b]
Groundwater	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Nitroaromatics	SW-846 3535/8330[a]
	PCBs	SW-846 3510C/8082[a]
	Total TAL Metals	SW-846 3005A/6010B/7470A[a]
	Dissolved TAL Metals	SW-846 3005A/6010B/7470A[a]
	Turbidity[c]	MCAWW 180.1[b]
	Alkalinity[c]	MCAWW 310.1[b]
	Hardness[c]	MCAWW 130.2[b]
	Total Dissolved Solids[c]	MCAWW 160.1[b]
	Total Suspended Solids[c]	MCAWW 160.2[b]
	Chloride[c]	MCAWW 325.3[b]
	Cyanide, total[c]	SW-846 9010A/9012[a]
	Nitrate[c]	MCAWW 352.1[b]
	Oxidation-reduction Potential (ORP)[c]	ASTM D1498-08[e]
	Sulfate[c]	MCAWW 375.3[b]
	Ferrous Iron	Hach test kit
Soil	TCL SVOCs	SW-846 3541/8270C[a]
	Nitroaromatics	SW-846 8330[a]
	PCBs	SW-846 3541/8082[a]
	TAL Metals	SW-846 3050B/6010B/7471A[a]
	TOC	Lloyd-Kahn
Solid IDW	TCLP Volatile Organic Compounds	SW-846 1311/5030B/8260B[a]
	TCLP Semivolatile Organic Compounds	SW-846 1311/3510C/8270C[a]
	TCLP Metals	SW-846 1311/3010A/6010B/7470A[a]
	Ignitability	SW-846 1010[a]
	Corrosivity	SW-846 1110[a]
	Reactivity	7.3.3.2/7.3.4.2[a]
Liquid IDW	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Total TAL Metals	SW-846 3005A/6010B/7470A[a]
	Ignitability	SW-846 1010[a]
	Corrosivity	SW-846 1110[a]
	Reactivity	7.3.3.2/7.3.4.2[a]

TCL - Target compound list; VOC - Volatile organic compound; SVOC - semivolatile organic compound; TAL - target analyte list
PCB - polychlorinated biphenyl; TCLP - toxicity characteristic leaching procedure; IDW - investigation-derived waste

[a]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition
[b]Analyses found in *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, March 1983 and subsequent revisions.
[c]Water quality parameter
[d]American Society for Testing and Materials.

Table 5-1

Analytical Methods, Preservatives, and Holding Times
Waste Water Treatment Plant No. 1 Sewer Lines
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater	TCL VOCs	SW-846 5030B/8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	PCBs	SW-846 3510C/8082	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Total TAL Metals	SW-846 3005A/6010B/7470A	(1) 100 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	Dissolved TAL Metals	SW-846 3005A/6010B/7470A	(1) 100 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Turbidity	MCAWW 180.1	(1) 250 mL HDPE	Cool to 4°C	48 hours
	Hardness	MCAWW 310.1	(1) 250 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
	TDS/TSS	MCAWW 160.1/160.2	(1) 250 mL HDPE	Cool to 4°C	7 days
	Alkalinity	MCAWW 310.1	(1) 250 mL HDPE	Cool to 4°C	14 days
	Chloride	MCAWW 325.3	(1) 250 mL HDPE	Cool to 4°C	28 days
	Total Cyanide	SW-846 9010A/9012	(1) 250 mL HDPE	Cool to 4°C, NaOH to pH >2	14 days
	Nitrate	MCAWW 352.1	(1) 250 mL HDPE	Cool to 4°C	48 hours
	Sulfate	MCAWW 375.3	(1) 250 mL HDPE	Cool to 4°C	28 days
	ORP	ASTM D1498-08	NA	NA	Performed in field
	Ferrous Iron	Hach test kit	NA	NA	Performed in field
Soil	TCL SVOCs	SW-846 3541/8270C	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction/40 days
	Nitroaromatics	SW-846 8330			14 days extraction/40 days
	PCBs	SW-846 3541/8082			14 days extraction/40 days
	TAL Metals	SW-846 3050B/6010B/7471A			6 months (28 days for Hg)
	TOC	Lloyd-Kahn			28 days

Table 5-1

Analytical Methods, Preservatives, and Holding Times
Waste Water Treatment Plant No. 1 Sewer Lines
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

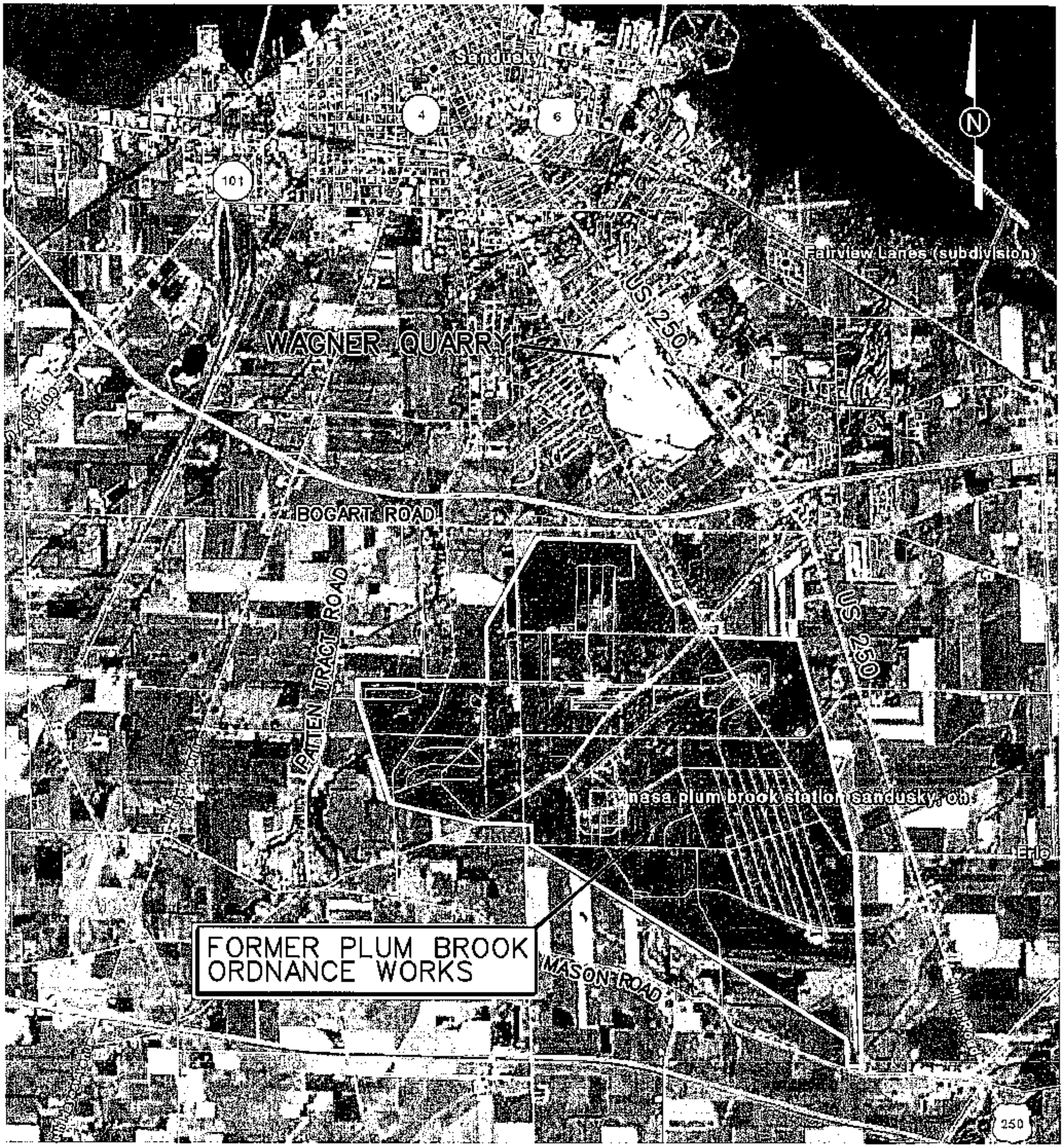
Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Liquid IDW	TCL VOCs	SW-846 5030B/8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(1) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	TAL Metals	SW-846 3005A/6010B/7470A	(1) 250 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	Ignitability pH Corrosivity Reactive Cyanide Reactive Sulfide	SW-846 1010 SW-846 9045B SW-846 1110 7.3.3/7.3.4 7.3.3/7.3.4	(1) 1 L Amber	Cool to 4°C	ASAP
Soil IDW	TCLP VOCs TCLP SVOCs TCLP Metals Ignitability Corrosivity Reactive Cyanide Reactive Sulfide	SW-846 1311/5030B/8260B SW-846 1311/3510C/8270C SW-846 1311/3010A/6010B/7470A SW-846 1010 SW-846 1110 7.3.3/7.3.4 7.3.3/7.3.4	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction 14 days extraction/40 days 14 days /ext./6 months (28 days for Hg) ASAP ASAP ASAP ASAP

°C - Degrees Celsius.
CWM - Clear wide mouth.
H_2SO_4 - Sulfuric acid.
HCl - Hydrochloric acid.
HDPE - High density polyethylene.
Hg - Mercury.
HNO_3 - Nitric acid.
L - Liter.
mL - Milliliter.

NaOH - Sodium hydroxide.
PAH - Polynuclear aromatic hydrocarbon.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TOC - Total organic compound.
VOC - Volatile organic compound.
IDW - Investigative-derived waste.
EPA - U.S. Environmental Protection Agency.
VOA - Volatile organic analysis.
OZ - Ounces.
Ext. - Extraction
ASAP - As soon as possible.

*Number of containers required in ( ).

FIGURES



NOT TO SCALE

FIGURE 1-1
PBOW VICINITY MAP

WWTP1 SEWER LINES SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 07/30/08	DATE LAST REV.:	DRAFT. CHCK. BY: C. BENTLEY	INITIATOR: D. KESSLER	132458_ssap_001.dgn
DRAWN BY: C. BENTLEY	DRAWN BY:	ENGR. CHCK. BY: T. SIARD	PROJ. MGR.: S. DOWNEY	PROJ. NO.: 132458

PBOW_standard.tbl Canon-color-Letter.plt
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132458_ssap_001.dgn 11/17/2008

RESPONSE TO COMMENTS

Draft Site-Specific Sampling and Analysis Plan
Waste Water Treatment Plant No. 1 Sewer Lines Remedial Investigation
Phase 1 Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Review comments from J. Byczkowski, Ohio Environmental Protection Agency, DERR.

Comment 1: **Section 2.3.5, page, 2-3. Currently, the U.S. EPA Region 5 does not promote the "*Regional Screening Levels*" (RSLs), adopted by Regions 3, 6 and 9. The Ohio EPA-DERR still recommends the Region 9 PRG Table (2004) for deriving risk-based screening levels (10% PRG for non-carcinogens and 100% PRG for carcinogens).**
Reference: OEPA – DERR (2004) Use of U.S. EPA Region 9 PRGs as screening Values in Human Health Risk Assessments. Technical Decision Compendium, 28 April 2004. On-line: http://www.epa.state.oh.us/derr/rules/screening.pdf.

Response 1: The text states that PRGs will be used, but allows that further team discussion may result in the use of Regional Screening Levels (RSLs). EPA and the Oak Ridge National Laboratory have jointly developed the RSL as an update to the Region 9, PRGs, Region 3 RBCs, and Region 6 MSSLs. The various regions have been involved in the development of the RSLs and have taken the position that these updated values should be used rather than the older region-specific values. The USACE also agrees with EPA concerning the use of these screening values and would like to discuss their adoption at a future team meeting. This text is included to express the potential for discussion of using the RSLs at PBOW.

Review comments dated October 16, 2008, from Julie Weatherington-Rice, Ph.D., RAB TAPP Coordinator, Bennett & Williams.

General Comments

Comment 1: **This document is much better written than the previously reviewed document. There is better connection and linkages between the sections, more references to topics that are discussed in more than one place. It is easier to follow and not as confusing or truncated for the reader. However, these are still addressed as two stand-alone documents. The two documents would benefit greatly by linkages between the two efforts as the Sewer Lines are directly related to the WWTP No. 1 project since it appears that they are physically attached to each other.**

Response 1: This is a sampling and analysis plan for the Waste Water Treatment Plant 1 (WWTP1) sewer lines, which runs from the TNTA settling basins and pump house to WWTP1. It is being performed separately from historical investigation of WWTP1 and TNTA and is intended as a stand-alone document for the purposes of sampling and analysis. Once the sampling and analyses are performed, there may be clear reasons to make connections between the WWTP1 sewer lines investigation and other PBOW investigations. If this is the case, such correlations will be made in the RI report.

Specific Comments

Comment 1: **<u>1.2 WWTP1 Sewer Line Description and History beginning on page 1-2</u>. The term "wood-stave sewer line" is NOT a common term or a common type of sewage transport system. It would help if there was a short discussion about why PBOW used wooden pipes to carry wastewater. Were there explosive hazards associated with using clay tile pipes or metal pipes?**

The second paragraph uses the abbreviation of WWTP1 and then spells out Wastewater Treatment Plant No. 2 and Wastewater Treatment Plant No. 3. This is an awkward sentence structure. It would be better to spell out all three in this setting with the correct abbreviations following in ( )'s in the sentence.

Response 1: The following statement will be added: "Note that wood-stave pipes were constructed of small wood slats (i.e., staves) joined together in a tongue-and-groove fashion and reinforced with steel banding. Use of wood-stave pipes was not uncommon for water and sewage conveyance during the late 1800s until the 1950s." Clay pipes would not have been a good choice for these sewer lines because they were pressurized; clay pipes tend to leak under pressure. Although cast iron might have otherwise been used, iron was one of many materials conserved for the war effort. Given the fairly common use of wood-stave pipe in the late 19th through the first half of the 20th century, especially during war times, it does not seem necessary to offer further explanation as to the composition of the pipes, nor does the composition of the pipes have any impact on the sampling design. Once the pipe is located, we will note the condition of the pipe and report this in the RI report. Similar wood-stave pipes found at West Virginia Ordnance Works were notably intact, even more than 60 years after use was discontinued.

With respect to the use of abbreviations, there is no reason to abbreviate for Waste Water Treatment Plants 2 and 3 because this is their only appearance in the document. Similarly, there is no reason not to abbreviate WWTP1 in the referenced sentence; this term has already been defined and used numerous times up to this point in the text, so the representation of this acronym to mean "Waste Water Treatment Plant No. 1" should be clear to the reader. To spell it out once more would serve no apparent purpose and would run contrary to our style convention. Note that a list of acronyms and their meanings is included on pages v and vi, should there be any question.

Comment 2: **<u>2.2 Objectives beginning on page 2-1</u>. There should be some linkage here to the projects for WWTPs 1 & 3 and Ash Pits 1 & 3. These projects will not be undertaken in a separate vacuum, especially the investigation of the WWTP1.**

Response 2: The objectives of the WWTP1 sewer line investigation are separate from the objectives of the investigations of these other PBOW areas. Where the findings of the sewer line RI are relevant to the findings of one of these other RIs, this will be duly noted in the RI reports.

Comment 3: **<u>3.1.1 Geophysical Survey Approach beginning on page 3-2</u>. Historically, the USDA Natural Resources Conservation Service and the Agricultural Research Service staff have had limited success in locating clay field tiles that were installed in Ohio using any of the geophysical survey approaches discussed. Wood pipes may react better and metal pipes certainly do, but is it realistic to expect to find metal banding on wooden pipes that have been in the ground for over 60 years? This section would benefit from a short discussion listing places where electromagnetic technology (EM) or magnetic gradiometry (MG) coupled with ground-penetrating radar (GPR) have been used successfully to find wood-stave sewer pipes. If there are no other successful applications, then it should be noted that this is an experimental application of this technique. There is nothing wrong with experimenting and undertaking pilot projects, but if they are used, fall-back techniques should be listed here as well although the fall-back techniques do not need to be fully discussed at this point in time.**

Response 3: We do not know of anybody who has used magnetometry, EM, or GPR to specifically locate a buried wood-stave sewer line. However, this does not render the approach described in the SSAP as experimental. Geophysics investigations should be able to detect pathways of a former trench. The metal banding on the wood-stave piping should provide readings so that further information will be known. (Note that the metal banding on wood-stave sewer lines at the West Virginia Ordnance Works were in relatively good conditions after more than 60 years of burial.) The banding on the sewer lines is made of steel, which is a ferrous material. Each of these methods has the ability to see ferrous materials as an anomaly (note that GPR does not specifically differentiate between ferrous and nonferrous metals). Essentially, the banding material should be detectable using these methods because of its composition; it matters not that the material is specifically in the form of banding. If the sewer line is not detected due to interferences or depth, the attempt to locate the sewer line will be continued based on historical information, field observations, and aerial photographs. The following statement will be added to Section 3.2.1 with respect to the test pits to be excavated along the sewer line: "Note that if the locations of the sewer line traces cannot be inferred from the results of the geophysical methods described in Section 3.1, an attempt will be made to find the sewer lines based on historical information, field observations, and aerial photographs. A review of current aerial photographs suggests linear scarring along the ground surface in the vicinities of these former lines."

Comment 4: **<u>3.3.3 Piezometer Installation page 3-9</u>. In discussing the installation and completion process for the piezometers, the following statements are made; "No filter pack material will be placed around the well screen. The top 1-2 feet of the borehole will be sealed with bentonite to prevent water or surface runoff from infiltrating the borehole". Given the nature of the natural materials expected to be intersected by the direct-push soil sampler and into which the piezometers are to be set, we SHOULD NOT expect the formation to collapse around the outside of the well screen creating a "natural pack" well. Therefore, since at least some annulus space is expected to be preserved between the inside of the bore hole and the outside of the well screen, how will the installers prevent the bentonite from moving down the boring annulus and clogging the PVC screen? Are they going to install some kind of packer or seal around the PVC to prevent migration downward? More explanation of installation and completion technique is needed here. It would be helpful to include Figure 4-5 of the SWSAP here to document how these piezometers are going to be installed.**

Why are the piezometers being abandoned after only one use? There needs to be more information placed here about how the granular bentonite will be emplaced and/or a reference to another location in the text where that is discussed.

Response 4: The referenced text in the first paragraph of Section 3.3.3 will be revised as follows: "… placed around the well screen. No filter pack material will be placed around the well screen. *Because the sampling will occur reasonably quickly after the piezometers have been installed, semi-permanent seals are not necessary.* The top 1 to 2 feet of the borehole will be sealed with bentonite to prevent precipitation water or surface runoff from infiltrating the borehole. *If sealing with bentonite proves difficult, a plastic surface seal may be used around the borehole and covered with additional soil or bentonite sloping away from the piezometer to promote runoff and prevent any surface water from entering the borehole.* Figure 4-5 of the …"

Comment 5: **<u>3.3.4.1 Monitoring Well Installation beginning on page 3-9</u>. The lay reader will not be familiar with "EM 1110-1-4000, *Monitor Well***

***Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites"* which incidentally is also not listed in the references. This section would be improved by including a short summary of how the wells will be installed, further documented by a figure showing the typical construction.**

Response 5: Additional description of monitoring well installation will be provided as follows: "Soil and rock core logging will be continuous for the entire drilling procedure during the monitoring well installation. The geologist/geotechnical engineer will visually classify and log all borehole material according to the unified soil classification system (USCS) and EM 1110-1-4000 (USACE, 1998). Soil overburden material will be sampled continuously for the purposes of visual classification of the borehole material, but samples will not be saved for geotechnical analysis. Soil boring samples collected during well installation processes will not be analyzed for chemical parameters, except for disposal characterization as described in Chapter 6.0.

Three overburden/shale and three limestone bedrock monitoring wells will be installed at each AOC. Borings for overburden/shale monitoring wells will be advanced 7 to 8 feet past the depth groundwater is encountered or until bedrock using hollow-stem auger drilling methods or other appropriate drilling methods. Two-inch inside diameter (ID) polyvinyl chloride (PVC) well material consisting of a 10-foot length screen and riser will be installed into the borehole. A filter pack will be tremied into the borehole to surround the screen and brought to a height of approximately 2 feet above the screen top. An approximate 2 to 5-foot bentonite seal will be tremied to depth above the filter pack followed with a neat cement/bentonite mixture (95% Type II or V Portland Cement and 5% bentonite powder mixed with 5 to 7 gallons clean water) to approximately 3 feet below grade.

Limestone bedrock borings will drill bedrock using a rock core bit cutting a maximum 6-inch outside diameter (OD) borehole and a rock core tube 5 feet in length. If a 6-inch OD rock bit is not used during bedrock drilling, after reaching the desired depth for monitoring well installation, the borehole will be reamed with a rotary bit to attain a 6-inch OD diameter borehole. This will allow a total of 4-inches of filter pack material to surround the 2-inch diameter screen placed in the borehole for the monitoring well. Upon removal of the rock core tube, measurement of the rock recovered compared to the run length (length of the bedrock drilled) will be made. If the rock core length does not match the run length, total depth of the borehole will be measured to determine if the rock core was lost or washed way. Mention of the lost core on the borelog will be made. Fractures (mechanical, natural, or healed) will also be included on the borelog.

After a lithologic interpretation of the rock core is completed, the bedrock core will be placed into a wooden or cardboard core box and photographed with a digital camera. Prior to photographing, the rock core will be sprayed with water to help distinguish the features of the rock core (color, fracturing, etc.). The top of the core run should be in the upper left of the photo and the bottom of the core in the lower right corner of the photo. A scale (i.e. rock hammer, note book, tape measure, etc.) will be included in the photo for distance approximation.

Construction of the limestone bedrock wells will follow the same requirements as the overburden/shale wells. Requirements are listed in EM 1110-1-4000 (USACE, 1998). Typical monitoring well installation and construction diagrams are included in the SWSAP (Shaw, 2008b)."

Comment 6: **<u>3.7 Abandonment on page 3-17</u>. Do they mean concrete which has aggregates included or do they mean cement? What is the concrete/water mix ratio used for the abandonment mix? How will the aggregates fit down the tremie pipe? Will bentonite be included in the mix? If so, at what rate?**

Reseeding success will depend on the time of the year that the seed is applied. What is the reseeding window for this project?

Response 6: The fourth bullet in this Section 3.7 text will be replaced with the following:

- *Neat cement grout, which uses a ratio of one 94-lb bag of Portland cement to no more than 6 gallons of water and 2 to 8 % bentonite powder will be used as the sealant.* This grout will be tremied from the bottom of the well screen until undiluted grout flows from the piezometer/well at the ground surface.

Abandonment of the piezometers/wells will be in accordance with Ohio Department of Natural Resources (ODNR) requirements, following OEPA (2005) guidance.