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January 15, 2009

U.S. Army Engineer District, Nashville
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Submittal of the Final Work Plan for the Remedial Investigation
Locomotive Building Area
Former Plum Brook Ordnance Works, Sandusky, Ohio
Contract No. W912QR-08-D-0013: Shaw Project Number 133767

Dear Ms. McClanahan:

In accordance with the requirements of Delivery Order No. DX06 of Contract No. W912QR-08-D-0013 Shaw is pleased to submit the Final Work Plan for the Remedial Investigation to be conducted at the Locomotive Building Area at the Former Plum Brook Ordnance Works located in Sandusky, Ohio.

Enclosed are four copies of this final plan. Copies have also been sent to those on the distribution list as indicated.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to contact me at (865) 694-7496.

Sincerely,

for Steven Downey

Steven T. Downey, PE, PMP
Project Manager

Enclosures

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DISCIPLINE SIGN-OFF REVIEW

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Client Name: U.S. Army Engineer District, Nashville; CELRN-EC-R

Project Description: Remedial Investigation of the Locomotive Building Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Contract No. W912QR-08-D-0013 Delivery Order No. DX06

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NOTICE: By signature above, parties certify that the subject document has been prepared by and/or reviewed by them (as appropriate), that all review comments have been resolved, and that the document is ready for submittal.

Attachment IV

Site-Specific Sampling and Analysis Plan
Remedial Investigation
Locomotive Building Area

Former Plum Brook Ordnance Works, Sandusky, Ohio

Prepared for:

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January 2009

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List of Acronyms

AOC	area of concern
ASTM	American Society for Testing and Materials
bgs	below ground surface
^{o}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
GMA	Garage Maintenance Area
GPR	ground-penetrating radar
GPS	global positioning system
IDW	investigation-derived waste
LBA	Locomotive Building Area
NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
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
SI	site inspection
Shaw	Shaw Environmental, Inc.
SSAP	site-specific sampling and analysis plan

List of Acronyms *(Continued)*

SVOC	semivolatile organic compound
SWSAP	sitewide sampling and analysis plan
TAL	target analyte list
TCL	target compound list
TOC	total organic carbon
TNT	trinitrotoluene
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound

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 District 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 Locomotive Building Area (LBA), which includes the Locomotive Shop and the Rail Car Washing Area. The Locomotive Shop is located north of Maintenance Road in the eastern part of the Garage Maintenance Area (GMA). The former Rail Car Washing Area is located east of the Locomotive Shop. This SSAP was developed in accordance with the PBOW sitewide 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 sitewide accident prevention/sitewide safety and health plan (Shaw, 2008c) has also been prepared for this investigation to help provide a safe work environment.

1.1 Plum Brook Ordnance Works 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, which is 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 the various PBOW areas of concern, including the LBA.

1.2 Summary of Existing Site Data

The most recent environmental investigation concerning LBA was presented by the USACE (2000), Louisville District in *Limited Site Inspection for the Former Plum Brook Ordnance Works, Garage Maintenance Building (Locomotive Building Area).*

As noted above, PBOW was built in early 1941 and manufactured 2,4,6-TNT, DNT, and pentolite until 1945. The GMA included Building 716B, which was used in the maintenance of various vehicles; Building 728, also used to perform vehicle maintenance; and Building 718, which was used specifically for locomotives maintenance. Building 718 and the nearby Rail Car Washing Area are the focus of this SSAP. Building 718 is herein identified as the Locomotive Shop.

The LBA is located in the central portion of the PBOW facility (Figure 1-2). The site areas that are the subject of the SSAP are the Locomotive Shop and the Rail Car Washing Area. The Locomotive Shop is located north of Maintenance Road in the eastern part of the GMA. The former Rail Car Washing Area is located east of the Locomotive Shop as shown on Figure 1-3.

The Locomotive Shop (Building 718) occupied the easternmost building in the GMA. The shop was used for the maintenance of equipment, vehicles, and rail cars. A work pit built to allow maintenance personnel to work below the locomotives is the primary area of concern in this building. The pit measures 60 feet long; 3 feet, 8 inches wide; and 5 feet deep (USACE, 2000). The pit is located beneath the northern set of railroad tracks that run through the Locomotive Shop. This work pit is labeled “Maintenance Pit” in the depiction on Figure 1-3. NASA has backfilled this pit with loose stone and currently uses this building as a storage garage. The pit was used to work on the rail cars and locomotives during the operation of PBOW. When the maintenance pit was operational, the waste effluent from the pit was sent into the sewer system via a sump pump. The sump measures 9 feet, 2 inches deep and 2 feet, 6 inches in diameter, and is located on the south side of the building. The pump is still present.

The Locomotive Shop was located south of a track known as “Z” track. “Z” track was labeled as being the track “to (the) caustic dock” (USACE, 2000). Three rubble piles were observed to the east of the Locomotive Shop; the exact contents of these piles are unknown, but visual examination indicated the presence of masonry materials.

The Rail Car Washing Area is located east of the Locomotive Shop, across Maintenance Road from Ash Pit #1. As shown on Figure 1-3, there are no buildings at the Rail Car Washing Area. During the operation of PBOW, this area was a pit used as the site of a locomotive car cleaning operation that involved an acid, thereby also referred to as the acid area in the limited site investigation (SI) (USACE, 2000). The Rail Car Washing Area surrounded the terminus of the southern track in the pair of railroad tracks that exited the Locomotive Shop from the eastern end of the building. This area was approximately 260 feet from the east wall of the Locomotive Shop. Today, the area is open land with moderate vegetative cover. The area is not located near any easily recognizable man-made structure other than the locomotive building.

Based on a 2008 site visit by USACE and Shaw personnel, the Locomotive Shop is used for equipment storage (e.g., backhoe tractor) and possibly maintenance. A visual site survey conducted in 1999 during the limited SI indicated the former pit located at the Rail Car Washing Area had been backfilled.

During the limited SI (USACE, 2000), samples were taken inside and outside the Locomotive Shop and in the Rail Car Washing Area (Figure 1-3). The USACE collected a total of 11 soil samples at the LBA. Seven samples from three soil borings were collected at the Rail Car Washing Area, one surface soil sample (0 to 2 feet) and six subsurface soil samples (three at 2 to 4 feet and three at 4 to 6 feet). From the Locomotive Shop, three samples were collected from soil boring SB01, one surface soil sample (0 to 0.5 feet) and two subsurface soil samples (one at 1 to 3 feet and one at 3 to 5 feet). A fourth sample was collected from the lowest reach of the maintenance pit (DP01) at a depth of 6 to 7.5 feet. A total of three surface water samples were collected, one from the sump located in the maintenance pit, one from the sewer (wastewater junction box), and one from the man-made ditch located in the area east of Building 718 which flows into a tributary of Plum Brook. One sediment sample was also collected from the ditch at the same location as the surface water sample. Sample locations are illustrated on Figure 1-3. One existing monitoring well (MNTA-BED-GW01) is located near the southeast corner of the Locomotive Building (Figure 1-3). Groundwater quality was not evaluated because groundwater sampling was beyond the scope of the limited SI.

Each soil sample was analyzed for semivolatile organic compounds (SVOC), target analyte list (TAL) metals, polychlorinated biphenyls (PCB), total organic carbon (TOC), with the exception of the two samples collected from 4 to 6 feet at the Rail Car Washing Area which were analyzed for TAL metals only. Surface water samples collected at the sump and sewer were analyzed for

SVOCs, TAL metals, and PCBs. The surface water and sediment samples from the ditch were analyzed for TAL metals only.

The results of the soil samples showed elevated concentrations of the PCB Aroclor 1260 at the Locomotive Shop and of 2,4-DNT and naphthalene at the Rail Car Washing Area, indicating residual material from past activities has contaminated these areas. Arsenic was also detected above the screening value from a sample collected at a depth of 4 feet from the Rail Car Washing Area. Lead, iron, arsenic, and Aroclor 1260 levels detected in the surface water sample collected from the sump exceeded their respective screening levels, as did arsenic and iron in the sediment sample collected from the ditch.

The observed concentrations of arsenic, Aroclor 1260, and 2,4-DNT detected at the LBA indicated contamination from past site activities; therefore, further investigation was recommended (USACE, 2000).

1.3 Sitewide 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. Overburden groundwater beneath the LBA is generally expected to be perched or trapped water of minimal quantities (USACE, 2000).

Based on data from monitoring wells installed closest to the area of concern (AOC), the overburden thickness near the LBA is expected to be approximately 26 feet, and the shallow water table is at 9 feet below ground surface (bgs). Overall, the water-producing ability of the overburden materials is strongly controlled by seasonal changes and varies spatially across the PBOW facility (IT Corporation, 1999). The overburden at the LBA site lies above the Olentangy Shale, which is continuous in the area along Maintenance Road. The shale bedrock is expected to be encountered at a depth of approximately 26 feet at the LBA and is calculated to dip to the southeast at a slope of approximately 21 feet per mile.

In general, groundwater flows in a northerly direction, towards Lake Erie, in both the unconsolidated overburden/shale material and the limestone bedrock, except on the western side of the installation, where the overburden/shale groundwater flows to the northwest. Both overburden/shale and deeper limestone groundwater underlying the LBA is 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), the LBA RI will be concluded with the preparation and submittal of a three-volume report.

RI field activities covered by this SSAP consist of the following tasks:

- Geophysical survey
- Soil sampling (using direct-push technology)
- Installation of temporary piezometers and monitoring wells
- Groundwater sampling of piezometers and wells
- Surface water and sediment sampling
- Laboratory analysis of soil, groundwater, sediment, and surface water 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, which will comprise Volume 1 of the RI report. This information will also be used in the baseline human health risk assessment and screening-level ecological risk assessment, which will comprise Volumes 2 and 3 of the RI report, respectively. A separate work plan will be submitted for Volumes 2 and 3.

2.2 Objectives

The primary objective of the LBA investigation is to determine the soil, sediment, surface water, and overburden and bedrock groundwater quality and the extent of contamination in those media. Specific objectives of the continued RI are summarized as follows:

- Evaluate and use existing data appropriate to the LBA.
- Define site physical features and characteristics.
- Determine nature and extent of DOD-related contamination in soil, sediment, surface water, and groundwater at the LBA.
- Determine chemical characteristics of contamination.
- Evaluate fate and transport of contamination.
- Determine if overburden groundwater underlying the LBA 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 U.S. Environmental Protection Agency (EPA) publication 9355.9-01, *Data Quality Objectives 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 on 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 to 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 human health and ecological receptors
- Types of contaminant of an affected medium.

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 overburden/shale groundwater and/or bedrock groundwater, soil, sediment, and surface water runoff to creeks. The bedrock groundwater is of sufficient volume to be used as a potable

water supply. Unless the RI shows otherwise, it is assumed that the overburden/shale groundwater well is also of sufficient volume to be used as a potable source.

The LBA site is located along Maintenance Road, away from the borders of the Plum Brook Station. NASA is currently using the Locomotive Shop as a storage garage. Plum Brook Station employees and contractors may have casual contact with the soil in the LBA incidental to routine utility servicing or maintenance activities. The possibility of trespassers being exposed to the LBA soil is not regarded as plausible because of the security fence and NASA security force. Although NASA opens areas of the installation to hunting, this does not include the LBA. The Rail Car Washing Area is not mowed and has a thick growth of low-height plants surrounding a pair of somewhat bare areas. The assumption for future land use is unrestricted. Potential ecological receptors at the LBA are wildlife communities, plant communities, and aquatic communities associated with creeks. 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 (VOC), SVOCs, metals, and PCBs.

2.3.4 Decision-Making Process, Data Uses, and Needs

The decision-making process that will be followed during the RI, as 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 and the previous investigation to the most current risk-based screening concentrations (RBSC). Groundwater and surface water RBSCs are currently derived from EPA (2004) preliminary remediation goal (PRG) tap water criteria, and soil and sediment 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, soil, surface water, and sediment 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 affect PARCCS.

3.0 Field Activities

The continued RI approach will be consistent with work conducted previously at the PBOW facility. Direct-push soil samples will be collected from 12 additional borings, as shown on Figure 1-3 (Section 3.2.1). This includes six borings in the vicinity of the Locomotive Shop, three borings in the vicinity of the Rail Car Washing Area, and three borings at the bottom of the former maintenance pit in the Locomotive Shop. A total of 10 piezometers will be installed at the LBA (Section 3.2.1). Proposed locations of soil borings and temporary piezometers have been selected using data and knowledge from the limited SI (USACE, 2000). Four overburden/shale and four limestone monitoring wells will be installed after the review of the analytical results of the piezometers (Section 3.4.2). Surface water and sediment samples will also be collected to determine the nature and extent of contamination at the LBA (Section 3.3). Geophysical survey methods will be used to locate any underground storage tanks (UST). A total of five borings were sampled as part of the limited SI (USACE, 2000), three at the Rail Car Washing Area and two at the Locomotive Shop. Thus, field activities under this SSAP will include the following:

- Geophysical survey activities to locate any USTs
- Collection of three soil samples at each of nine newly installed direct-push soil boring locations, six borings in the vicinity of the Locomotive Shop, and three borings in the vicinity of the Rail Car Washing Area.
- Collection of one soil sample at each of three direct-push boring locations installed in the maintenance pit where a sample shall be collected from only the deepest 1 foot of material (based on the limited SI Report, the pit is 8 feet deep).
- Collection of 10 sediment and 10 collocated surface water samples.
- Installation of 10 piezometers.
- Sampling of groundwater from the piezometers.
- Installation of four overburden/shale and four limestone monitoring wells.
- Sampling of the monitoring wells (two rounds of sampling).
- Management and disposal of IDW.

All boring and well locations will be sketched and surveyed; land elevations will be surveyed to within $\pm$ 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 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 magnetometry, coupled with subsequent confirmation using ground-penetrating radar (GPR) to locate any USTs in the area. The geophysical survey will be conducted around the entire building and within 100 feet of the building on the east, north, and west, and to Maintenance Road on the south.

First, the survey team will walk the immediate vicinity of the former Locomotive Building to review topographic, vegetation, and access issues and identify to what extent these factors may affect the survey. The survey will be conducted around this building, as this is the most likely area where USTs may be located. The EM or magnetometry survey pattern will consist of consecutive passes spaced approximately 5 or 10 feet apart, depending on the equipment selection. To ensure that full coverage is obtained over the entire survey area, the operator will navigate through several methods, including 1) observing the tracks of previous lines and offsetting the new line to obtain overlapping coverage, or 2) the use of spray paint or portable markers to mark the position of lines and then offsetting the new lines. EM or magnetometry data will be collected at 1-second intervals.

Anomalies observed using EM or magnetometry will be field checked immediately following the survey to differentiate between those caused by surface and subsurface sources. 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 USTs 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 magnetometry. This technology will be used within each EM or magnetometry transect. The GPR transects will generally be shorter than the EM transects because it is anticipated that the GPR survey will focus on the anomalies identified during the EM or magnetometry survey that appear to be

potentially indicative of the presence of a UST. If neither EM nor magnetometry is effective in locating any USTs, GPR will still be tried, but it is doubtful that GPR alone would prove useful in locating a UST.

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 270- 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 UST 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 the 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.

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 and 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 excavation to confirm the anomaly.

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, is used to map the presence of pipelines, utilities, USTs, 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 mapping more tabular features, such as ground conductivities. Because 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 GPR Equipment

GPR surveys will be conducted to further characterize source materials responsible for observed EM 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.

3.1.2.3 Magnetometry Equipment

Magnetometers, particularly the Geometrics G858g magnetic gradiometer, are ideally suited for detection and characterization of ferrous targets, such as the metal components of a UST. Thus, magnetometers are the sensor of choice for many sites. They are usually preferable to EM sensors when the targets are ferrous; when 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.

3.1.2.4 Global Positioning System

Because site conditions are favorable (no tree canopy and no large man-made structures), the single frequency Trimble PRO XRS or AG114 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 Remedial Investigation

Soil samples will be collected from each of 12 soil borings. 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 3.2.2. Table 2-2 summarizes the samples, and Table 3-1 identifies the specific analytical parameters and methods.

3.2.1 Direct-Push Soil Samples

A total of 12 borings will be advanced at LBA, 3 borings in the vicinity of the Rail Car Washing Area, 6 borings in the vicinity of the Locomotive Shop, and 3 borings in the maintenance pit within the Locomotive Shop building. Figure 1-3 shows the proposed soil boring locations. As noted on Figure 1-3, one soil boring/piezometer at the Locomotive Shop will be placed based on the results of the geophysical survey. A total of 30 samples will be collected from the 12 borings. Three soil samples, one from 0 to 1 foot bgs, one from 3 to 5 feet bgs, and one from 8 to 10 feet bgs, will be collected from each boring at the Rail Car Washing Area and the Locomotive Shop, for a total of 27 samples. One sample will be collected from only the deepest 1 foot of each of the three soil borings installed in the maintenance pit, for a total of three samples. Because fill may have been brought into some areas of the site, Shaw will approximate the original soil surface and collect surface soil samples to 1 foot below this depth. The intermediate sample currently planned at a depth of 3 to 5 feet may be moved based on site-

specific conditions. The 8- to 10-foot interval will be collected at the respective depth below current ground surface. If bedrock is encountered at a depth of less than 10 feet bgs, then the deepest sample within a boring will be collected from bedrock to 2 feet above bedrock. Similarly, if groundwater is encountered prior to reaching 10 feet bgs, then the deepest soil interval will be sampled from the top of the groundwater to 2 feet above the groundwater.

The 30 samples (and 3 duplicates) will be analyzed for nitroaromatics, target compound list (TCL) VOCs, TCL SVOCs, and TAL metals. PCBs will be analyzed in the surface soil samples and those collected from 3 to 5 feet bgs (21 samples). One surface soil (0 to 1 foot) sample will be analyzed for TOC. Table 3-1 summarizes the samples and analytical parameters.

3.2.2 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, EM 1110-1-4000 (USACE, 1998) on the hazardous, toxic, and radioactive 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. 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 3.4.3), etc. Figure 4-5 of the SWSAP shows a typical piezometer construction form that will be completed for all piezometers. 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 3.2.1, borings will be advanced and soil samples will be collected using direct-push drilling technology. Details of soil collection methodology are described in Section 4.5 of the SWSAP (Shaw, 2008a). 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, four of the borings in the vicinity of the Locomotive Shop will be advanced to bedrock (or refusal) and a piezometer will be installed, as described in Section 3.4.3. Continuous logging will be performed to the bottom of the borehole.

With respect to the eight borings in which a piezometer will not be installed, these 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. 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, 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 Surface Water and Sediment Sampling

A surface water and sediment sampling effort will be conducted for the LBA. Ten sediment samples and 10 collocated surface water samples, if present, will be collected. Each sediment sample will be analyzed for TCL VOCs, TCL SVOCs, nitroaromatics, PCBs, and TAL metals.

In addition, one sediment sample will be analyzed for TOC. Each surface water sample will be analyzed for TCL VOCs, TCL SVOCs, nitroaromatics, PCBs, and TAL metals; one sample will be analyzed for hardness. Sediment samples will be collected at a depth of 0 to 6 inches if sediment is present to this depth. If water is not present in sufficient quantity at any of these locations, professional judgment will be used to identify an appropriate alternative location, if it exists. Table 3-1 summarizes the samples and analytical parameters. Figure 3-1 shows six proposed sample locations; four additional sediment/surface water samples may be collected based on field conditions.

3.4 Groundwater Remedial Investigation

Groundwater will be investigated in a phased approach. First, temporary piezometers will be installed in a total of four soil sampling borings drilled at the Locomotive Shop (Figure 3-1), with the location of one of the borings determined by the geophysical survey. Six additional piezometers will be installed at the LBA, two at the Locomotive Shop and four at the Rail Car Washing Area. Each of these borings will be advanced to bedrock and a continuous lithologic log recorded. Based on the analytical results and groundwater flow patterns of the piezometer samples, four monitoring wells will be installed in the overburden/shale and four monitoring wells will be installed in the underlying limestone formation. Each piezometer and monitoring well will be sampled using the low-flow technique described in Section 3.4.7, unless OEPA and USACE approve a variation. Table 3-1 summarizes the samples and analytical parameters.

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.

3.4.1 Piezometer Samples

A total of 10 piezometers will be installed at the LBA, as described in Section 3.2.2. Once soil sampling is complete and the associated soil sample is collected (Section 3.2.1), the boring will be advanced to bedrock (or refusal). As described in Section 3.2.2, the boring will be continuously logged, with lithologic and hydrologic observations appropriately recorded. Piezometer installation is described in Section 3.4.3. Each piezometer water sample will be collected using a low-flow technique and analyzed at a laboratory for TCL VOCs, TCL SVOCs,

nitroaromatics, TAL dissolved metals (filtered), total metals (unfiltered), and water quality parameters. Also, ferrous iron will be analyzed in the field using a test kit. 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 for monitoring wells to be installed in the two groundwater zones (i.e., overburden/shale and underlying limestone). To expedite the overall schedule, these samples will be analyzed on a 7-day turnaround.

3.4.2 Monitoring Well Samples

A total of eight wells will be installed at LBA, based on the analytical results of the piezometer samples. Four of these eight monitoring wells will be installed in the overburden/shale and the other four wells will be installed in the limestone bedrock. The specific location of each well will be determined by the geologist/geotechnical engineer, based on the analytical results of the piezometer samples.

Each monitoring well will be sampled using a low-flow technique (Section 3.4.7) and analyzed at a laboratory for TCL VOCs, TCL SVOCs, nitroaromatics, dissolved (filtered) metals, total (unfiltered) metals, and water quality parameters. Also, ferrous iron will be analyzed in the field using a test kit. 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. All monitoring wells for this investigation will be installed just prior to the first sampling event. During the second sampling event, the condition of all surface components of the monitoring wells sampled will be documented with the recommendation for repair, if necessary. 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.

3.4.3 Piezometer Installation

Temporary piezometers are typically used to measure static water levels and collect groundwater quality samples in commonly slow recharging environments. The LBA 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,

semipermanent 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 3.4.7.

Following the groundwater level measurement associated with the first round of monitoring well sampling (Section 3.4.2) and permission from USACE, the PVC material (PVC screen and casing) will be removed from all temporary piezometer 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 will be cut into 5-foot manageable lengths, decontaminated using the procedure described in Section 4.3, and discarded into the local sanitary trash.

3.4.4 Monitoring Well Installation and Development

3.4.4.1 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 eight new monitoring wells.

The estimated depth for each of the four new overburden/shale wells is 20 feet, and the estimated depth for each of the four 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 3745-9-03, *Monitoring Well*. Where necessary, the geologist/geotechnical engineer will anticipate using "double casing" as described in Section 3-10 of USACAE (1998) to install a well through a contaminated upper zone. A well log will be completed and filed on line with ODNR (http://www.dnr.state.oh.us/water/maptechs/submitlogs/). All monitoring well drill cuttings will be drummed, labeled, and handled as described in Chapter 6.0.

3.4.4.2 Monitoring Well Development

Each monitoring well will be developed using a submersible pump or bailer as soon as practical, but no sooner then 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 1 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 5 percent of the length of the well screen.
- Temperature, pH, and 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 of this water 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.

3.4.5 Water Level Monitoring

After the LBA 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, which is marked during surveying (Section 3.0).

The water elevations of all eight monitoring wells will be measured at once prior to purging the first well (Section 3.4.7). 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 LBA. The depth to water will be measured to the nearest 0.01 foot from the northern edge of the riser (inner casing), which is marked during surveying. Note that the piezometers will be abandoned after this measurement, as described in Section 3.4.3. Therefore, the water levels of only the eight monitoring wells will be measured as part of the second monitoring well sampling event.

3.4.6 Groundwater Sampling Equipment

The equipment required for groundwater sampling includes the following:

- Water level indicator
- Low-flow submersible 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/lower explosive limit 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.

3.4.7 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 3.4.5). The monitoring wells will be purged and sampled a minimum of 14 days after development (Section 3.4.4.2), unless a variance is agreed to by 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 3.4.3).

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 photoionization detector/lower explosive limit 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 sitewide safety and health plan 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 an electric submersible pump or a bladder pump will be used to complete the sampling. The pump 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 to 500 milliliters per minute. 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 prepumping (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 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 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 (^{o}C)
  - Turbidity (three consecutive readings less than 100 NTUs)
  - Dissolved oxygen +/-1%
  - Conductivity +/-3% of reading.

- For slow recharging wells or piezometers, field parameters will be recorded after sampling to ensure adequate volume is available for the chemical analysis.

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

- Containers 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 milliliters per minute. 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 $4^{o}C$) and delivered to the laboratory in sufficient time that specified holding times are not exceeded. Details of the sample preservation, packing, and shipping are provided in Chapter 5.0.

In addition to the primary water samples, certain field QC samples will be prepared as described in succeeding text. 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).

3.5 Land Surveying

Following completion of soil sampling and temporary piezometer 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 previously. Once sample survey information is available, it will be entered on approved Shaw boring logs. Critical reference points, landmarks, and sample locations will be plotted on appropriate map figures with a scale large enough to show their locations relative to other structures at the site.

3.6 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.

3.7 Site Access

All Shaw personnel and subcontractors will meet each morning at the NASA/Plum Brook Station, white/red barn area, or other “headquarters” type area for the morning tailgate safety/job

safety analysis 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. 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 NASA (former PBOW) facility will be appropriately trained and instructed by Plum Brook Station concerning site safety issues. All Shaw personnel and any subcontracted personnel involved must be a U.S. citizen.

3.8 Well 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 the 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 mixture using 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 tremied from the bottom of the boring until undiluted grout flows from the borehole/well at the ground surface.

- 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 will 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
SE – sediment sample
SW – surface water sample
GW – groundwater sample
MS – matrix spike
MD – matrix spike duplicate

[b]Site:

LBA – Locomotive Building Area.

[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* (EPA, 1996) and its subsequent updates. They will meet the QA/QC requirements outlined in 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* (DOD, 2006). Project-specific reporting limits are included in Tables 7-1 through 7-4 of the QAPP. 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 text summarizes decontamination procedures for equipment before site entry, between borings, and before site departure:

Nonsampling equipment (direct-push rods, augers, drill rods, etc., that do not contact analytical samples) and abandoned well materials:

- 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 precleaned, and made of materials recommended by EPA in Title 40, Code of Federal Regulations, Part 136 and SW-846 (EPA, 1996). 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

IT Corporation, 1999, *Summary Report*, ***Site-Wide Groundwater Monitoring (1997-1998), Former Plum Brook Ordnance Works, Sandusky, Ohio***, February.

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Ohio Environmental Protection Agency (OEPA), 2005, ***Technical Guidance for Ground Water Investigations, Chapter 9, Sealing Abandoned Monitoring Wells and Boreholes***, Revision 1, Division of Drinking and Ground Waters, Columbus, Ohio, February.

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U.S. Army Corps of Engineers (USACE), 2000, ***Final Report, Limited Site Inspection for the former Plum Brook Ordnance Works, Garage Maintenance Building (Locomotive Building Area),*** July.

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U.S. Department of Defense (DOD), 2006, ***Quality Systems Manual for Environmental Laboratories***, Final Version 3, DoD Environmental Data Quality Workgroup, Department of Navy, Lead Service, January.

U.S. Environmental Protection Agency (EPA), 2004, ***Region 9 Preliminary Remediation Goals (PRG) Table,*** Region 9, San Francisco, California, October, http:www.epa.gov/region09/waste/sfund/prg/files/prgtable.pdf.

U.S. Environmental Protection Agency (EPA), 1996, ***Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods***, EPA Publications SW-0846, Third Edition, Update III, (http://www.epa.gov/sw-846/sw846.htm).

U.S. Environmental Protection Agency (EPA), 1993, ***Data Quality Objectives for Superfund: Interim Final Guidance***, OSWER Directive No. 9355.9-01, Office of Emergency and Remedial Response, Washington, D.C., EPA 540-R-93-071.

TABLES

Table 2-1

Summary of Data Quality Objectives
Locomotive Building Area
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 OEPA DOD USACE NASA Shaw Other Contractors Possible Future Land Users	Previous environmental investigations show varying degrees of contamination in the soil.	<u>Contaminant Source</u> Production of TNT, DNT, and pentolite. Past DOD operations. <u>Migration Pathways</u> Soil, sediment, surface water, and groundwater. <u>Potential receptors</u> Wildlife, human. <u>Potential Contaminants of Concern</u> SVOCs, metals, PCBs, and explosives.	Groundwater Surface Water Sediments Soil	Evaluate and use existing data appropriate to the LBA. Define site physical features and characteristics. Determine nature and extent of DOD-related contamination in soil, sediment, surface water, and groundwater. Determine chemical characteristics of contamination. Evaluate fate and transport of contamination. Determine if overburden groundwater underlying the LBA is sufficient in 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. Obtain site data of quality, quantity and distribution appropriate for site characterization, risk assessment, and feasibility study.	<u>Groundwater</u> Metals Explosives SVOCs VOCs Water quality parameters <u>Surface Water</u> SVOCs Explosives Metals Hardness <u>Soil</u> Metals Explosives PCBs SVOCs TOC <u>Sediments</u> Metals Explosives PCBs SVOCs TOC	Definitive Screening level

DNT - Dinitrotoluene.
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.
LBA - Locomotive Building Area.
SVOC - Semivolatile organic compound.
TNT - Trinitrotoluene.
Shaw - Shaw Environmental, Inc.
TOC - Total organic carbon.
PCB - Polychlorinated biphenyls.
VOC - Volatile organic compound.

Table 2-2

Summary of Analytical Samples
Locomotive Building Area
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Direct-Push Soil Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	30	3	2	1	NA	3/3
TCL VOCs	30	3	2	1	NA	3/3
TCL SVOCs	30	3	2	1	NA	3/3
PCBs	21	3	2	1	NA	3/3
TAL Metals	30	3	2	1	NA	3/3
Total Organic Carbon	1	NA	NA	NA	NA	NA
Sediment Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	10	1	1	NA	NA	1/1
TCL VOCs	10	1	1	NA	NA	1/1
TCL SVOCs	10	1	1	NA	NA	1/1
PCBs	10	1	1	NA	NA	1/1
TAL Metals	10	1	1	NA	NA	1/1
Total Organic Carbon	1	NA	NA	NA	NA	NA
Surface Water Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	10	1	1	NA	NA	1/1
TCL VOCs	10	1	1	NA	NA	1/1
TCL SVOCs	10	1	1	NA	NA	1/1
TAL Metals	10	1	1	NA	NA	1/1
Hardness	1	NA	NA	NA	NA	NA
Piezometer Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	10	1	1	1	NA	1/1
TCL VOCs	10	1	1	1	NA	1/1
TCL SVOCs	10	1	1	1	NA	1/1
Metals (Filtered)	10	1	1	1	NA	0
Metals (Total)	10	1	1	1	NA	1/1
Water Quality Parameters [a]	10	NA	NA	NA	NA	NA

Table 2-2

Summary of Analytical Samples
Locomotive Building Area
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Monitoring Well Samples [b]						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	16	2	2	2	NA	2
TCL VOCs	16	2	2	2	2	2
TCL SVOCs	16	2	2	2	NA	2
Metals (Filtered)	16	2	2	2	NA	0
Metals (Total)	16	2	2	2	NA	2
Water Quality Parameters [a]	16	NA	NA	NA	NA	NA

TCL - Target compound list.
VOC - Volatile organic compound.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
PCB - Polychlorinated biphenyl.
QA - Quality assurance.
QC - Quality control.

[a] Refer to Table 3-1 (footnote "c") for groundwater quality parameters.
[b] Two rounds of sampling--a total of 8 new wells.

Table 3-1

Summary of Analytical Parameters and Methods
Locomotive Building Area
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters	Analytical Method
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[c]	ASTM D1498-08[d]
	Ferrous iron[c]	Hach test kit
	Sulfate[c]	MCAWW 375.3[b]
Surface water	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Nitroaromatics	SW-846 3535/8330[a]
	TAL Metals	SW-846 3005A/6010B/7470A[a]
	Hardness[c]	MCAWW 130.2[b]
Soil	TCL VOCs	SW-846 5030B/8260B[a]
	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]
	Total Organic Carbon	Walkley-Black
Sediments	TCL VOCs	SW-846 5030B/8260B[a]
	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]
	Total Organic Carbon	Walkley-Black
Liquid IDW	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Nitroaromatics	SW-846 3535/8330[a]
	TAL Metals	SW-846 3005A/6010B/7470A[a]
	Ignitability	SW-846 1010[a]
	Corrosivity	SW-846 1110[a]
	Reactivity	7.3.3/7.3.4[a]
Solid IDW	TCL VOCs	SW-846 1311/5030B/8260B[a]
	TCL SVOCs	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	7.3.3/7.3.4[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, Containers, Preservatives, and Holding Times
Locomotive Building Area
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)
	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
	Ferrous iron	Hach test kit	NA	NA	performed in field
	ORP	ASTM D1498-08	NA	NA	performed in field
Surface Water	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
	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)
	Hardness	EPA 130.2	(1) 100 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
Soil	TCL VOCs	SW-846 5030B/8260B	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction
	TCL SVOCs	SW-846 3541/8270C			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	Walkley-Black			28 days

Table 5-1

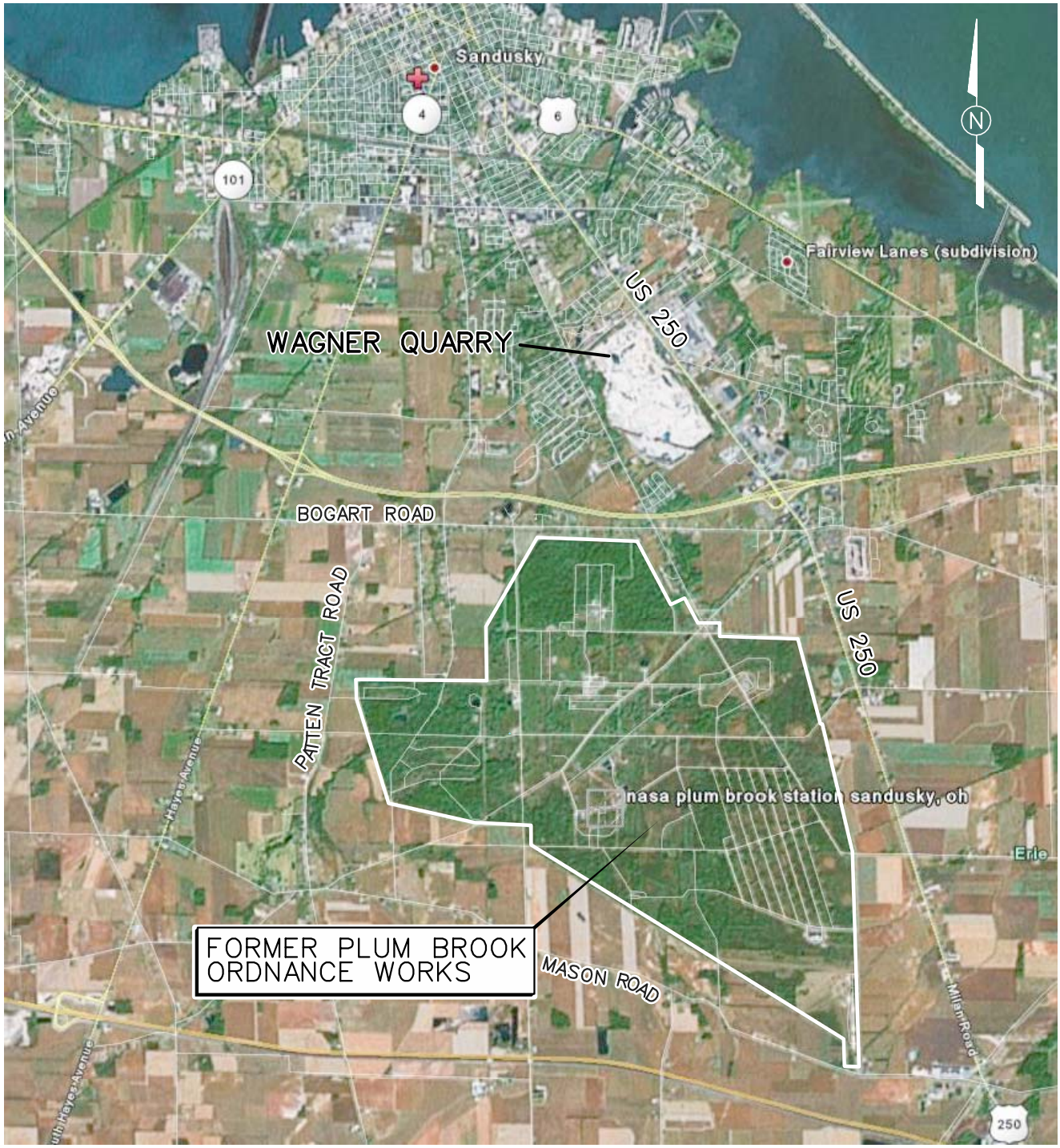
Analytical Methods, Containers, Preservatives, and Holding Times
Locomotive Building Area
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Sediments	TCL VOCs	SW-846 5030B/8260B	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction
	TCL SVOCs	SW-846 3541/8270C			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	Walkley-Black			28 days
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	SW-846 1010	(1) 1 L Amber	Cool to 4°C	ASAP
	pH	SW-846 9045B			
	Corrosivity	SW-846 1110			
	Reactive Cyanide	7.3.3/7.3.4			
	Reactive Sulfide	7.3.3/7.3.4			
Solid IDW	TCLP VOCs	SW-846 1311/5030B/8260B	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction
	TCLP SVOCs	SW-846 1311/3510C/8270C			14 days extraction/40 days
	TCLP Metals	SW-846 1311/3005A/6010B/7470A			14 days /ext./6 months (28 days for Hg)
	Ignitability	SW-846 1010			ASAP
	Corrosivity	SW-846 1110			ASAP
	Reactivity	7.3.3.2/7.3.4.2			ASAP

°C - Degrees Celsius.
CWM - Clear wide mouth.
H_2S0_4 - Sulfuric acid.
HCI - Hydrochloric acid.
HDPE - High-density polyethylene.
Hg - Mercury.
HNO_3 - Nitric acid.
L - Liter.
mL - Milliliter.
NA - Not applicable.
NaOH - Sodium hydroxide.
ORP - Oxidation-reduction potential.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TOC - Total organic carbon.
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

LOCOMOTIVE BUILDING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 11/04/08	DATE LAST REV.:	DRAFT. CHCK. BY:	INITIATOR: D. KESSLER
DRAWN BY: S. MCCAWLEY	DRAWN BY:	ENGR. CHCK. BY:	PROJ. MGR.: S. DOWNEY

133767_ssap_001.dgn
PROJ. NO.: 133767

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11/19/2008

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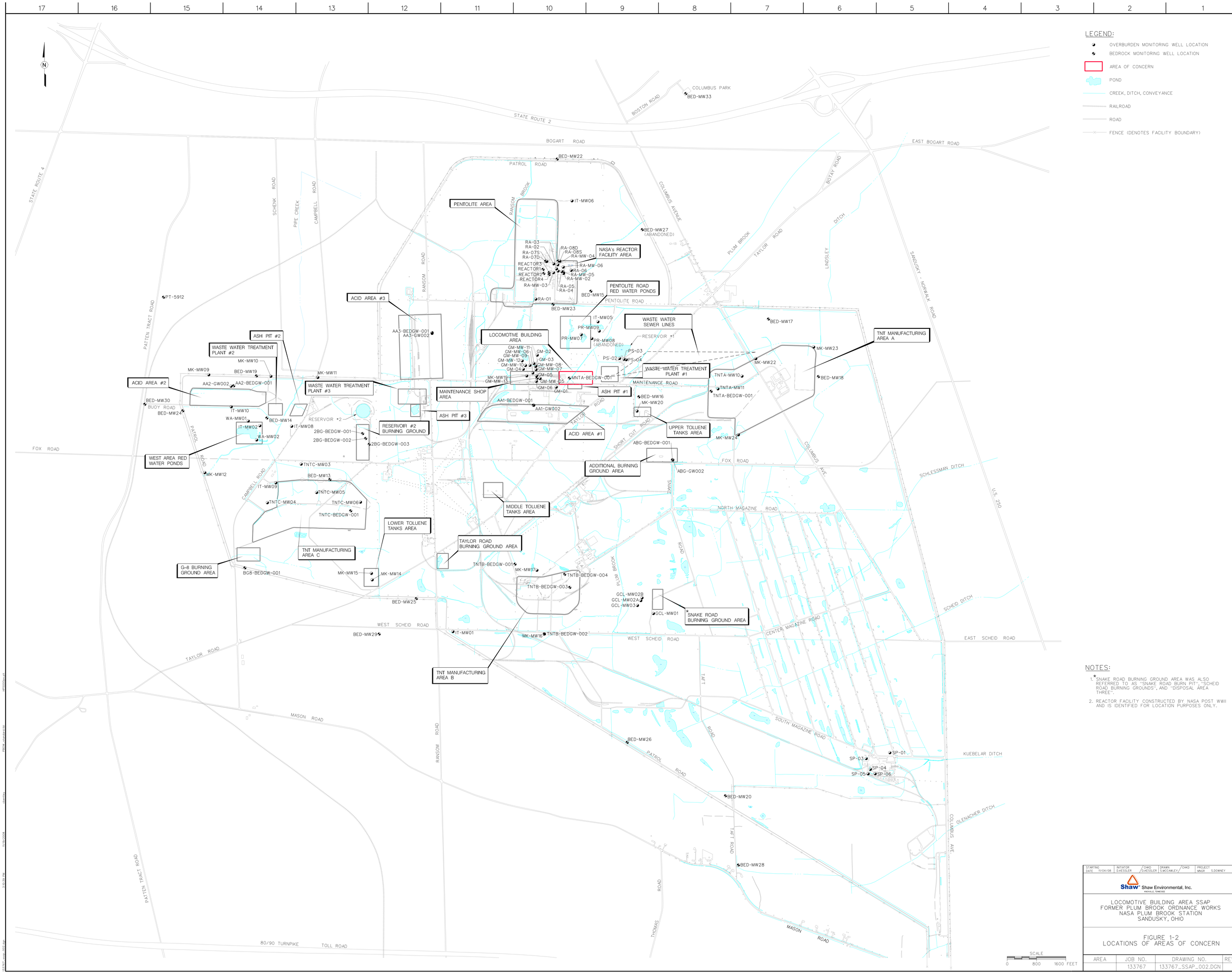
cbentley
133767_ssap_001.dgn



NOTES:

1. *SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

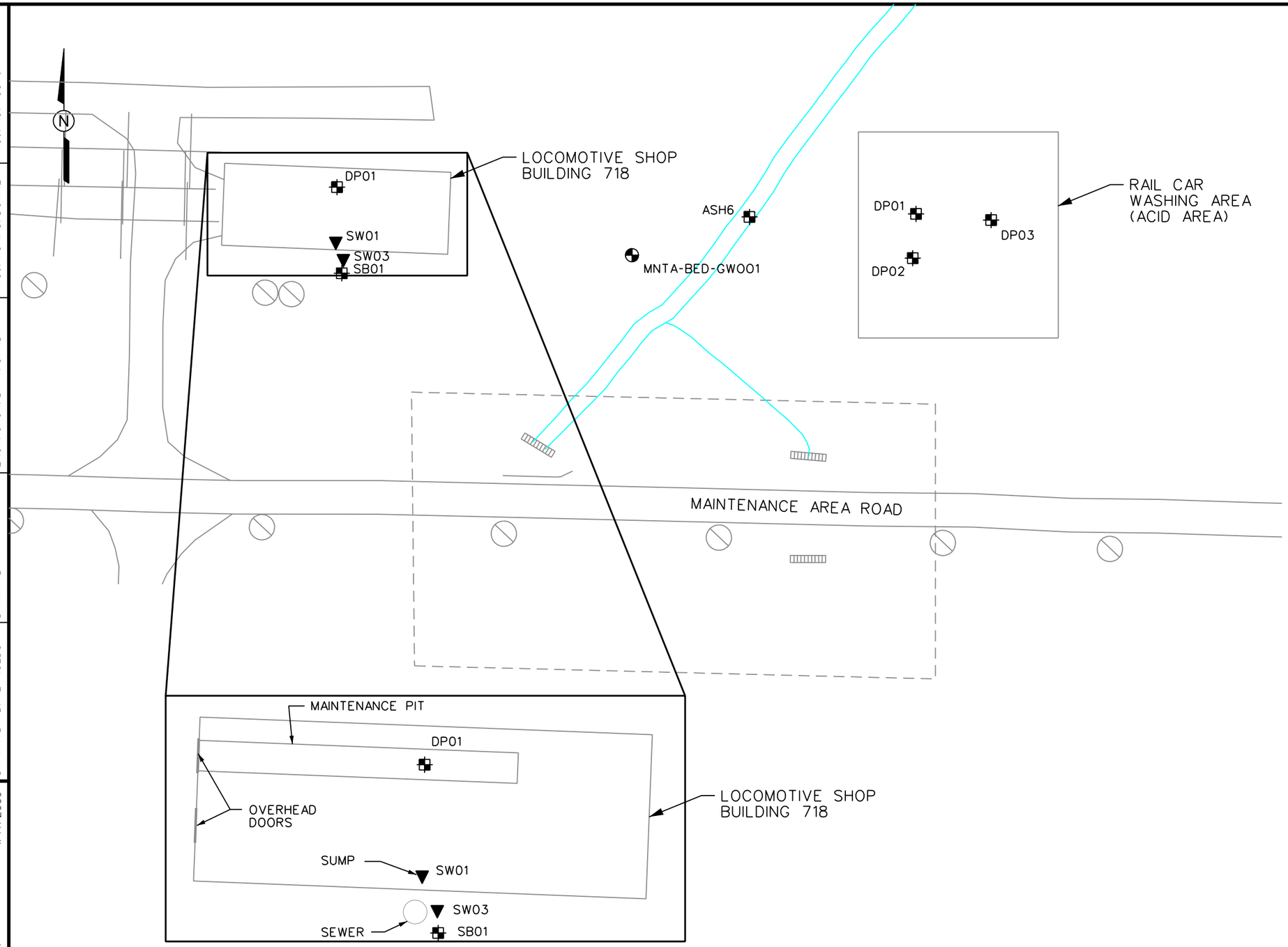
STARTING DATE 11/04/08	INITIATOR D.KESSLER	CHKD D.KESSLER	DRAWN S.MCCAWLEY	CHKD	PROJECT MNGR S.DOWNEY

Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

LOCOMOTIVE BUILDING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN

AREA	JOB NO.	DRAWING NO.	REV
	133767	133767_SSAP_002.DGN	



LEGEND:

- HEADWALL
- UTILITY POLE
- EXISTING BEDROCK MONITORING WELL
- PREVIOUS SOIL BORING (USACE, 2000)
- PREVIOUS SURFACE WATER SAMPLE (USACE, 2000)

LOCOMOTIVE SHOP	EASTING	NORTHING	ELEV.
DP01	1918532.01	623846.90	N/A
SW01	1918531.31	623814.93	N/A
SW03	1918535.59	623805.16	N/A

RAIL CAR WASHING AREA	EASTING	NORTHING	ELEV.
DP01	1918860.51	623831.73	636.7
DP03	1918903.13	623828.21	636.8
DP02	1918858.68	623806.58	637.5

NOTES:

1. PREVIOUS SOIL SAMPLES COLLECTED IN 1999 (USACE, 2000, LIMITED SITE INVESTIGATION, FINAL REPORT, FOR THE FORMER PLUM BROOK ORDNANCE WORKS GARAGE MAINTENANCE BUILDING (LOCOMOTIVE BUILDING AREA), SANDUSKY, OHIO, JULY).

SCALE
0 60 120 FEET

FIGURE 1-3
HISTORIC SAMPLING LOCATIONS

LOCOMOTIVE BUILDING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

133767_ssap_003.dgn
PROJ. NO.: 133767
INITIATOR: D. KESSLER
PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. BENTLEY
ENGR. CHCK. BY: T. SIARD
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 01/14/09
DRAWN BY: B. REYNOLDS
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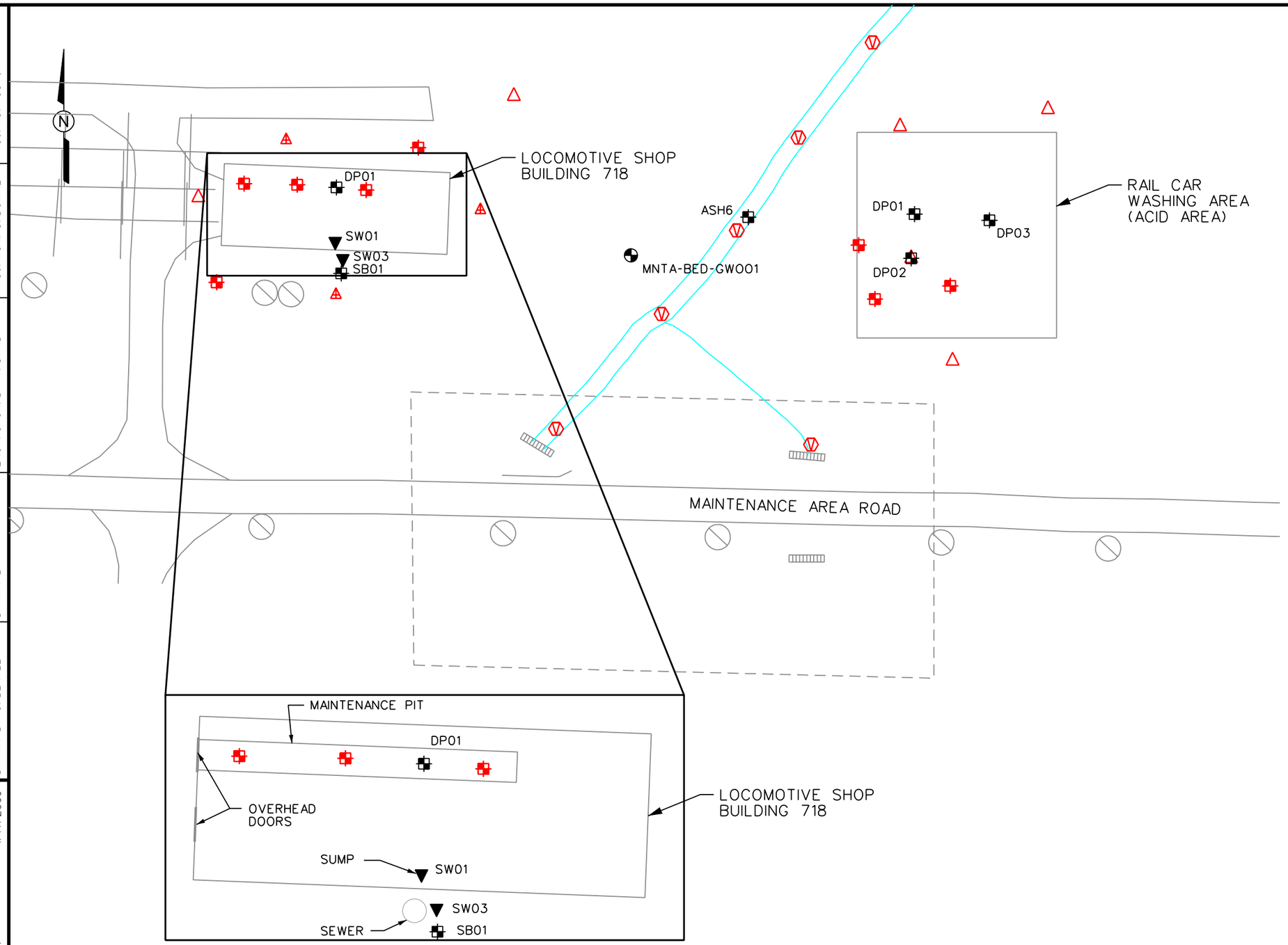
ben.reynolds
133767_ssap_003.dgn



LEGEND:

- HEADWALL
- UTILITY POLE
- EXISTING BEDROCK MONITORING WELL
- PREVIOUS SOIL BORING (USACE, 2000)
- PREVIOUS SURFACE WATER SAMPLE (USACE, 2000)
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER
- PROPOSED PIEZOMETER
- PROPOSED SURFACE WATER/SEDIMENT

NOTES:

1. PROPOSED LOCATIONS MAY BE MOVED BASED ON FIELD OBSERVATIONS.
2. FOUR ADDITIONAL SURFACE WATER/SEDIMENT SAMPLES MAY BE COLLECTED BASED ON FIELD CONDITIONS.
3. ONE SOIL BORING/PIEZOMETER AT THE LOCOMOTIVE SHOP WILL BE PLACED BASED ON RESULTS OF THE GEOPHYSICAL SURVEY.

SCALE
0 60 120 FEET

FIGURE 3-1
PROPOSED SAMPLING LOCATIONS

LOCOMOTIVE BUILDING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

133767_ssap_004.dgn
PROJ. NO.: 133767
INITIATOR: D. KESSLER
PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. BENTLEY
ENGR. CHCK. BY: T. SIARD
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 08/06/08
DRAWN BY: C. BENTLEY
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1/14/2009
PBOW_standard.tbl
ben.reynolds
133767_ssap_004.dgn

RESPONSE TO COMMENTS

Response to Comments
Draft Site-Specific Sampling and Analysis Plan
Locomotive House Area
Former Plum Brook Ordnance Works Sandusky, Ohio
November 21, 2008

Review comments from Janusz Byczkowski, Risk Assessor, Nashville District, received December 30, 2008

Comment 1: **Section 1.2, Page 1-4, 1st paragraph. This Document states: "…*samples showed elevated concentrations of the PCB Aroclor 1260* […] *2,4-DNT and naphthalene* […] *Arsenic was also detected above the screening value* […] *Lead, iron*…" and then:**
"…*therefore, further investigation was recommended*…"

There is no information in this document regarding numerical values of the screening levels which were used as criteria to recommend further investigation.

Please note, that Ohio EPA-DERR (2004) currently recommends the U.S. EPA Region 9 PRG Table (2004) for deriving risk-based screening levels (10% PRG for non-carcinogens and 100% PRG for carcinogens). Please assure that the reporting levels for chemicals in the respective media are below those screening levels.

Response 1: This text is a brief summary of results from the limited site inspection (LSI) report, as referenced, which was finalized in 2000. According the LSI report, Region 9 PRGs were used as the screening values. The date of these screening values is not provided, but because the LSI report is dated July 2000, the PRGs probably would not have been more recent than 1999. Also, it appears that the soil values are residential values, as they generally are slightly less than the 2004 PRGs, likely the result of a slightly different exposure assumption. The surface water PRGs appear to be based on then-current tap water PRGs, which are generally the same as current tap water PRG values. It is also noted that the straight PRGs were used for noncarcinogens, rather than the 10% PRGs.

It is understood that the use of 2004 PRGs, especially assuming the 10% PRG for noncarcingenic effects, may have resulted in somewhat different and likely additional chemicals identified as having elevated concentrations and consequently driving risk based on the LSI data. However, it is not the intent of this Work Plan to re-evaluate or re-interpret the results of the 2000 LSI report risk-based screening, or discuss potential discrepancies that may be obtained using the current approach. As discussed in Section 2.3.5 of the Work Plan, it is agreed that screening levels are currently based on the 2004 PRG values. Unless the project team should decide otherwise, the 2004 PRGs

will be used to screen the Locomotive House Area remedial investigation analytical sample results.

Region 9 PRGs have been developed as strictly risk-based values without any consideration given to the current state of technology. Thus, the existence of a PRG at a given concentration should not be construed to indicate that current analytical methods are able to detect or current technologies can remediate to this level, as the expectation that a given PRG should be met is not necessarily realistic. Instead, the goal of the PBOW analytical program is to obtain the best data currently possible, given the state of the technology. Generally, the RLs will meet the PRGs. However, for a few chemicals, it may be impossible for the RLs and even the method detection limits (MDL) to attain the PRG level. If such cases arise, these will be addressed in the site characterization and baseline human health risk assessment reports.