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January 21, 2009

U.S. Army Engineer District, Nashville
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Nashville, Tennessee 37203

Submittal of the Final Work Plan
For Phase 2 of the Remedial Investigation
Waste Water Treatment Plants 1 and 3 and Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio
Contract No. W912QR-08-D-0013: Shaw Project Number 132457

Dear Ms. McClanahan:

In accordance with the requirements of Delivery Order DX02 of Contract No. W912QR-08-D-0013, Shaw is pleased to submit the Final Work Plan for Phase 2 of the Remedial Investigation to be conducted at Waste Water Treatment Plants 1 and 3 and Ash Pits 1 and 3 at the Former Plum Brook Ordnance Works 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 S. Downey

Steven T. Downey, PE, PMP
Project Manager

Enclosures

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DISCIPLINE SIGN-OFF REVIEW

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

Project Description: Phase 2 RI at Waste Water Treatment Plants 1 and 3 and Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Contract No. W912QR-08-D-0013 Delivery Order No. DX02

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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 V

Final
Site-Specific Sampling and Analysis Plan
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3
and Ash Pits 1 and 3

Former Plum Brook Ordnance Works, Sandusky, Ohio

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Shaw Project Number 132457

January 2009

(This Site-Specific Sampling and Analysis Plan must be used in conjunction with the Site-Wide Sampling and Analysis Plan)

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List of Acronyms

AOC	area of concern
AP1	Ash Pit No. 1
AP3	Ash Pit No. 3
ASTM	American Society for Testing and Materials
^{o}C	degrees Celsius
D&M	Dames and Moore, Inc.
DNT	dinitrotoluene
DOD	U.S. Department of Defense
DQO	data quality objective
Eh	oxygen reduction potential
EPA	U.S. Environmental Protection Agency
IDW	investigation-derived waste
NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
OD	outside diameter
OEPA	Ohio Environmental Protection Agency
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
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
Shaw	Shaw Environmental, Inc.
SI	site investigation
SSAP	site-specific sampling and analysis plan
SWSAP	site-wide sampling and analysis plan

List of Acronyms *(Continued)*

SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
VOC	volatile organic compound
WARWP	West Area Red Water Pond
WWTP	waste water treatment plant
WWTP1	Waste Water Treatment Plant No. 1
WWTP2	Waste Water Treatment Plant No. 2
WWTP3	Waste Water Treatment Plant No. 3

1.0 Project Description

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

Shaw Environmental, Inc. (Shaw) has prepared this site-specific sampling and analysis plan (SSAP) for Phase 2 fieldwork to be carried out in support of groundwater remedial investigations (RI) at two former waste water treatment plant (WWTP) areas, Waste Water Treatment Plant No. 1 (WWTP1) and Waste Water Treatment Plant No. 3 (WWTP3), and at two ash pit areas, Ash Pit No. 1 (AP1) and AP No. 3 (AP3). Phase 1 sampling activities and associated fieldwork will begin prior to the start of Phase 2 and are described in the Phase 1 SSAP (Shaw, 2008a). The results of the Phase 1 investigation will be used to determine the placement of groundwater monitoring wells outlined in this SSAP. This SSAP must be used in conjunction with the site-wide sampling and analysis plan (SWSAP) (Shaw, 2008b), to which this SSAP has been prepared as an attachment, and the quality assurance project plan (QAPP) (Shaw, 2008c) to ensure that work performed at the subject site will be of the quality required to satisfy the overall and site-specific project objectives. A site-wide accident prevention/site-wide safety and health plan (Shaw, 2008d) has also been prepared for this investigation to help provide a safe work environment.

1.1 PBOW Site 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 during the last quarter of 1945. The property was initially excessed to the Ordnance Department after it was certified by the Army to be decontaminated. Part of the property (2,800 acres then known as the Magazine Area) was withdrawn from excess in 1946. The War Assets Administration accepted custody of the remaining acreage (approximately 3,230 acres) in 1946. The Department of the Army

reacquired the 3,230 acres in 1954 and performed cleanup efforts during the 1950s through 1963. A property use agreement was entered into by the National Advisory Committee of Aeronautics, the predecessor of NASA, and the Army in 1958. In 1963, accountability for and custody of the entire PBOW property (6,031 acres) was transferred to NASA by the General Services Administration. The Judge Advocate General, Department of the Army, Washington, D.C., became the custodian of title for the property.

1.2 Summary of Historical Site Data

The only previous investigations at WWTP1, WWTP3, AP 1, and AP3 areas were conducted by the USACE Louisville District in June 1999. The results were reported in *Final Report, Limited Site Investigation for the Former Plum Brook Ordnance Works, Waste Water Treatment Plants No. 1 and 3* (USACE, 2000a) and *Final Report, Limited Site Investigation for the Former Plum Brook Ordnance Works, Ash Pits No. 1 and 3* (USACE, 2000b).

The discussion of existing site soil and groundwater data will focus on the primary areas to be investigated under this RI. Although groundwater data are not subject to risk assessment screening in this SSAP, risk-based screening concentrations (RBSC) are included as points of reference. The groundwater RBSCs are derived from U.S. Environmental Protection Agency (EPA) (2004) Region 9 preliminary remediation goal (PRG) tap water criteria. The RBSCs are based on a generalized residential drinking water scenario, assumed to be the most restrictive use of groundwater. It is emphasized that RBSCs do not infer a regulatory limit or mandated cleanup level.

1.2.1 Waste Water Treatment Plant Areas

Three WWTPs (WWTP1, Waste Water Treatment Plant No. 2 [WWTP2], and WWTP3) at PBOW received waste water from TNT manufacturing operations. Figure 1-2 shows the areas of concern (AOC). WWTP1 is located nearest to TNT Area A (TNTA) and received waste water from the settling basins located at TNTA and from TNT Area B (TNTB). WWTP2 received waste water from TNT Area C (TNTC) and is located northeast of the West Area Red Water Pond (WARWP), east of Acid Area No. 2, and north of TNTC. WWTP3 is located between WWTP1 and WWTP2 and northwest of TNTB (Figure 1-2). The purpose of the plants was to reduce the volume of waste water discharged from each of the manufacturing areas to the WARWP and Pentolite Road Red Water Pond waste water ponds. The waste water that was received from TNT manufacturing areas consisted of spent sulfuric and nitric acids and red water from the TNT purification process. Chemicals in the waste streams included sodium salts of sulfite, sulfate, nitrite, nitrate, sulfonates of unwanted TNT isomers, trinitrobenzoic acid,

trinitrobenzaldehyde, trinitrobenzyl alcohol, nitrotoulenes, and dinitrotoluenes (Dames and Moore, Inc. [D&M], 1996).

Each of the WWTPs consisted of a neutral storage tank, an equalization tank, a condensate storage tank, an evaporator building, an incinerator, and a thick liquid storage tank. WWTP1 also included a caustic storage tank and a raw waste storage tank. The plants received waste water from the TNT manufacturing settling basins and neutralized the slurry through a chemical depuration process. The liquid was discharged to open ditches or ponds surrounding the facilities or thickened by evaporation. The thickened liquid was then incinerated. The incinerators were located to the east of the storage tanks at WWTP1 and to the north of the storage tanks at WWTP3. Ash from the incinerator was disposed of in nearby ash pits associated with the WWTPs (USACE, 2000a). Figure 1-3 shows a historic layout of WWTP1 and WWTP3, which are further discussed in the following text.

1.2.1.1 WWTP1

The former WWTP1 is located in the northern midsection of PBOW, approximately 200 feet northeast of the intersection of Maintenance Road and Taylor Road (Figure 1-2). It occupies approximately 2 acres of land. A former building located approximately 200 feet northeast of WWTP1 is still present and is currently used by NASA.

Limited investigation has been conducted at WWTP1. Historical drawings were reviewed by D&M (1995), and it was determined that the raw waste storage tank located at the former WWTP1 received waste from the settling basins located at manufacturing areas TNTA and TNTB.

During a field reconnaissance by Morrison-Knudsen Ferguson Corporation in March 1999, bare areas and the remains of concrete foundations were reported where the former buildings and/or storage tanks were once present. One soil sample was collected at WWTP1, but analytical results did not show any significant contamination (USACE, 2000a).

The most recent investigation was conducted by USACE in September 1999 and presented in a limited site investigation (SI) (USACE, 2000a). Nine surface soil samples were collected with a hand auger from a depth interval of 6 to 12 inches. Each soil sample location was advanced adjacent to or within the footprint of each identified foundation. Sediment samples were also collected from an unnamed drainage ditch located approximately 300 feet northwest of the site. No water was present in the drainage ditch, so surface water samples could not be collected. The analyte list included volatile organic compounds (VOC), semivolatile organic compounds

(SVOC), nitroaromatics, metals, polychlorinated biphenyls (PCB), and asbestos. Not all samples were analyzed for all compounds.

No VOCs were detected in soil or sediment samples that exceeded the PRGs for residential soil. No SVOCs were detected above PRG screening levels in soil and sediment samples. Two soil samples exhibited nitroaromatic 2,4,6-TNT above the then-current PRG screening level of 15 parts per million (ppm); one sample collected near the raw waste storage tank was at a concentration of 130 ppm, and the other, a duplicate sample collected near the thick liquid storage tank, was at a concentration of 170,000 ppm (a possible field collection or laboratory error is suspected due to the significant difference between sample results and also a laboratory reanalysis test). Nitroaromatics were not detected in sediment samples. Arsenic was the only metal detected above the PRG in soil and sediment samples, and concentrations ranged from 3.0 to 11.0 ppm, but results were consistent with background levels. No surface soil samples exhibited PCB concentrations above PRG limits, and no asbestos fibers were detected in any of the soil samples selected to be analyzed. Sediment samples were not analyzed for PCBs or asbestos (USACE, 2000a).

1.2.1.2 WWTP3

Former WWTP3 is located in the western midsection of PBOW, approximately 650 feet southwest of the intersection of Maintenance Road and Ransom Road and 450 feet southeast of the patrol road. It occupies approximately 2 acres of land (Figure 1-2). The neutralized waste water storage tank of former WWTP3 had been used by NASA as the K-Site Test Facility control building (USACE, 2000a). Operations at the K-Site Test Facility were officially abandoned in 2007; however, it is possible that the facility may be used for test programs in the future. D&M conducted a review of records in 1995 and found that a bermed, square depression north of WWTP3 and south of Maintenance Road may have been used as an ash settling basin.

In September 1999, 16 surface soil samples were collected with a hand auger from a depth interval of 6 to 12 inches as part of the limited SI. Fourteen soil sample locations were determined by tape measured distances from the existing former neutralized storage tank, and two surface soil samples were collected within a depression north of the site. The 14 soil sample hand auger borings were advanced adjacent to or within the footprint of each identified foundation or structure. Sediment samples were also collected from an unnamed drainage ditch located approximately 300 feet west of the site. No water was present in the drainage ditch, so surface water samples were not collected. The analyte list included VOCs, SVOCs, nitroaromatics, metals, PCBs, and asbestos. Not all samples were analyzed for all compounds.

Two surface soil samples collected from the depression north of WWTP3 exhibited only traces of the VOC methylene chloride, a common laboratory contaminant. Nitroaromatics were not detected in either sample, and arsenic was detected above the PRG in both samples at concentrations of 5.80 and 6.10 milligrams per kilogram. One soil sample collected near the former incinerator building exhibited the SVOC compounds benzo(a)anthracene (1,200 parts per billion [ppb]), benzo(a)pyrene (1,300 ppb), benzo(b)fluoranthrene (1,200 ppb), and ideno(1,2,3-cd)pyrene (870 ppb) above the PRG screening levels. No SVOCs were detected above PRG screening levels in sediment samples. No soil or sediment samples analyzed for nitroaromatics were above screening levels. Arsenic was the only metal detected above the PRG in soil and sediment samples, and concentrations ranged from 3.6 to 6.7 ppm; results were consistent with background levels. No surface soil samples exhibited PCB concentrations above PRG limits, and no asbestos fibers were detected in any of the soil samples selected to be analyzed. Sediment samples were not analyzed for PCBs or asbestos (USACE, 2000a).

1.2.2 Ash Pit Areas

As noted previously, PBOW was built in early 1941 and manufactured 2,4,6-TNT, DNT, and pentolite until 1945. Three power stations, Power House 1, Power House 2, and Power House 3, were constructed and utilized to support the TNT manufacturing process. Each power station consisted of a main powerhouse, a coal storage area, and an aboveground fuel storage tank. The fuel storage tank was surrounded by a berm to contain any potential spills or leaks. Each power house building consisted of a boiler house, compressor room, electrical room, filter room, and locker room. The buildings also contained two to four large coal-burning boilers, a turboelectric generator, a feed water treatment system, and several steam-driven or electric air compressors. The generated steam was used for space heating, driving compressors, and generating electrical power. Coal ash generated from each of the boilers in the powerhouse was collected in pits. Water was added to the ash, producing a slurry that flowed through a sluice trench to an ash sump located at the end of each power house. From the ash sump, the ash slurry traveled through a pipeline to a nearby surface water/ash impoundment (ash pit) (USACE, 2000b). Figure 1-2 shows the location of the three ash pit areas on PBOW property. Figure 1-3 shows a historic layout of AP1 and AP3, which are discussed in Sections 1.2.2.1 and 1.2.2.2, respectively.

Based on topographical quadrangles (dated 1959 and 1969), aerial photographs, and a visual site survey conducted in 1999, AP3 was noted to have essentially remained unchanged. AP1 has currently become overgrown with thick vegetation and, due to the basically level terrain, is believed to have been backfilled and graded. When NASA acquired PBOW property in the 1960s, the power plant facility at Power House 3 was remodeled to become the K-Site Test

Facility. At the time of the 1999 USACE limited RI report, the K-Site Test Facility was in operation and supplied noncontact cooling water to the former ash pit, to the extent that it held water. The exact depth of the water in the pit is unknown, but would not have been greater than a few feet. A pipe at the northeastern corner of the pit had supplied the cooling water. It is possible that this is the original pipe that once supplied the ash slurry to the pit. Boundaries of the pit appear to be the same as the original boundaries, with the exception of an indention to the west on the eastern boundary (USACE, 2000b). As discussed in Section 1.2.2.2, the K-Site Test Facility is no longer operational, and AP3 is typically no longer ponded.

1.2.2.1 AP1

AP1 is located in the central part of PBOW, approximately 1,100 feet west of the intersection of Maintenance Road and Taylor Road and approximately 50 feet south of Maintenance Road (Figure 1-2).

In June 1999, the USACE conducted a limited SI of AP1 (USACE, 2000b). AP1 was noted to be overgrown with thick vegetation and a thicket of small trees ranging from 3 to 8 feet tall. Personnel were informed by NASA that an underground, high-voltage utility line bisected AP1 in a north-south direction and an underground telephone line was present approximately 5 feet south and parallel to Maintenance Road. The USACE also noted a culvert under Maintenance Road and an associated drainage ditch approximately 5 feet due north of AP1. A larger drainage ditch located northwest of AP1 contained water and was flowing in a northeast direction. During an October 2008 site visit, USACE and Shaw personnel observed water in this ditch, but it did not appear to be flowing.

USACE collected five surface (0-1 foot) soil samples, one subsurface (4 feet) soil sample, and one collocated surface water-sediment sample. Each sample was analyzed for SVOCs and metals. Two subsurface soil samples were also analyzed for total organic carbon and geotechnical parameters. SVOCs were not detected in any of the samples. Fourteen metals were detected in soil samples, 12 were detected in the sediment sample, and 2 were detected in the surface water sample. Several metals exceeded the PRG screening level, so further investigation was recommended (USACE, 2000b).

1.2.2.2 AP3

AP3 is located approximately 800 feet southwest of the intersection of Maintenance and Ransom Road and is west of the former NASA K-Site Test Facility research building (former Power House 3) (Figure 1-2). Operations at the K-Site Test Facility were officially abandoned in 2007; however, it is possible that the facility may be used for test programs in the future. Abandoned

railroad tracks running in a north-south direction are located immediately east of AP3. The pit is partially surrounded by thick vegetation, with mature and smaller trees. Water had been discharged from the former pond by means of an east-west-trending drainage ditch that eventually discharges into Pipe Creek (USACE, 2000b).

During a June 1999 limited SI, USACE collected three surface water and two sediment samples. Two of the surface water and sediment samples were collocated. One pair was collected near the ash pit slurry entry location, one pair near the pit discharge, and the single surface water sample was located approximately 100 feet downgradient from the ash pit discharge. Each sample was analyzed for SVOCs and metals. SVOCs were not detected in any of the samples. One metal, arsenic, was detected above the screening levels in each of the surface water samples. A total of 12 metals were detected in the sediment samples, 2 exceeding PRG screening limits. Several metals exceeded the PRG screening level; therefore, further investigation was recommended (USACE, 2000b).

A review of aerial photographs indicates a lack of open water at AP3 in recent history. NASA (2008) personnel communicated that no water was present in AP3 on July 22, 2008. This was also the case during a September 2008 site visit by USACE and Shaw personnel, although a small ponded area was observed after a rain event during an October 2008 site visit.

1.3 Site-Wide Hydrogeology

Two hydrolithologic units are known to exist at PBOW. The overburden unit, composed of glacial outwash materials, has a thickness ranging from a few feet in the south to more than 40 feet in some locations in the north. Based on data from monitoring wells installed closest to the AOC, the overburden thickness near WWTP1 is expected to be around 17 feet, with the water-bearing interval expected to be at 8 feet below the ground surface. At AP1, the overburden thickness is expected to be at around 27 feet and the shallow water table at 9 feet. The overburden thickness at WWTP3 and AP3 is expected to be at a shallow depth of 15 feet and the overburden water at 5.5 feet. Overall, the water-producing capacity of the overburden materials is strongly controlled by seasonal changes and varies spatially across the PBOW facility (IT Corporation, 1999). The locations of all four investigation areas are initially underlain by the Plum Brook Shale, followed by the Delaware Limestone. The shale bedrock is expected to be encountered at depths ranging from 15 feet at WWTP3/AP3, 17 feet at WWTP1, and possibly 27 feet at AP1. Both the Plum Brook Shale and Devonian Limestone dip to the southeast at approximately 35 feet per mile.

In general, groundwater flows in a northerly direction, towards Lake Erie, in both the unconsolidated overburden material and the bedrock. However, on the western side of the installation, groundwater in the overburden water-bearing zone flows to the northwest, while groundwater in the bedrock aquifer flows to the northeast.

2.0 Scope of Work and Objectives

2.1 Scope of Work

As specified in the scope of work (USACE, 2008a), Phase 2 RI activities for WWTP1 and 3 and AP1 and 3 covered by this SSAP consist of the following tasks:

- Installation of overburden/shale and limestone bedrock monitoring wells
- Development of newly installed monitoring wells
- Groundwater sampling of monitoring wells
- Surface water and sediment sampling
- Laboratory analysis of groundwater, surface water, and sediment samples
- Management and disposal of investigation-derived waste (IDW)
- Preparation and submittal of a geographic information system deliverable.

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

2.2 Objectives

The primary objective of Phase 2, in conjunction with Phase 1 analytical results for these sites (Shaw, 2008a), is to determine the soil (Phase 1), surface water, sediment, and overburden and bedrock groundwater quality and the extent of potential chemicals of concern at the AOCs. Specific objectives of the continued RI are summarized as follows:

- Evaluate and use existing data appropriate to the AOCs
- Define site physical features and characteristics
- Determine nature and extent of DOD-related contamination in soil and groundwater at the AOCs
- Determine chemical characteristics of contamination
- Evaluate fate and transport of contamination
- Determine if overburden groundwater underlying the AOCs is in sufficient volume and quality to be defined as a potential drinking water source in the state of Ohio
- Obtain site data of quality, quantity, and distribution appropriate for site characterization, risk assessment, and feasibility study.

2.3 Site-Specific Data Quality Objectives

2.3.1 Overview

The data quality objectives (DQO) process is followed during the planning stages of the RI to evaluate data requirements needed to support the decision-making process and to select the best action to satisfy these requirements. Incorporated components of the DQO process, described in EPA Publication 9355.9-01, *Data Quality Objectives Process for Superfund* (EPA, 1993), are discussed in detail in Section 3.3 of the SWSAP. Determining factors for procedures necessary to satisfy investigative objectives and to establish the basis of future actions at PBOW are presented on Figure 3-1 of the SWSAP (Shaw, 2008b).

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 so that they can conclude whether the investigative effort is adequate to satisfy the study objectives.

2.3.3 Conceptual Site Model

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

- Potential contaminant sources
- Migration pathways
- Potential human health and ecological receptors
- Types of contaminant of an effected media.

A source of contamination at PBOW is past TNT manufacturing activities, including the production and storage of raw materials. Sources at the proposed areas of investigation result from TNT and DNT disposal activities. The migration pathways for potential contaminants include 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 is also of sufficient volume to be used as a potable source.

Exposure of site workers to potential contaminants under current land use at PBOW is unlikely, because these four sites are remote from regular site worker activity. Although NASA does open areas of the facility during hunting season to control the deer population, WWTP1, WWTP3, AP1, and AP3 areas are not permitted hunting grounds. The assumption for future land use is unrestricted. Future off-site residents are assumed to be exposed to current groundwater concentrations via migration of contaminants in groundwater. Potential ecological receptors at WWTP1, WWTP3, AP1, and AP3 are wildlife communities, plant communities, and aquatic communities associated with creeks. Note that groundwater in the vicinity of the sites 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 VOCs, 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, presented in detail in Section 3.3.4 of the SWSAP (Shaw, 2008b), 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 RBSCs. Groundwater RBSCs are currently derived from EPA (2004) PRG tap water criteria, and soil RBSCs are derived from residential soil PRGs. For chemicals in surface water and sediment, tap water and residential soil PRGs, respectively, are used. Depending on further PBOW team discussion and potential future agreements, the regional screening levels (Oak Ridge National Laboratory-EPA, 2008) may be used rather than PRGs to derive RBSCs in the future. 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, as described in Chapter 4.0 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, Representiveness, 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

Phase 2 RI activities will be based upon Phase 1 RI soil and groundwater analytical results. Three overburden/shale and three limestone bedrock monitoring wells will be installed and developed at each of the four AOCs. Figures 3-1 through 3-4 show proposed Phase 1 soil boring and piezometer installation locations. Specific locations of the monitoring wells will be determined based on the analytical results of the soil boring and/or piezometer samples. Surface water and sediment samples will also be collected in Phase 2 to supplement the analytical data from those collected during the 2000 WWTP (USACE, 2000a) and ash pit limited SI (USACE, 2000b). Thus, field activities under this SSAP will include the following:

- Installation and development of three overburden/shale and three limestone monitoring wells at each WWTP and ash pit (totals 12 overburden/shale and 12 limestone bedrock wells)
- Subsurface lithologic soil/rock sampling
- Collection of 12 sediment and 12 collocated surface water samples (4 collocated surface water/sediment samples from WWTP1, 3 from WWTP3, 2 from AP1, and 3 from AP3)
- Sampling of the monitoring wells (two rounds of sampling)
- Land surveying
- Management and disposal of IDW.

All boring and well locations will be sketched and then surveyed to the nearest 0.1 foot referenced to the State Plane Coordinate System; 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 referenced to the State Plane Coordinate System (Section 3.3). A notch will be filed into the top of the well riser, or the top of the riser will be otherwise marked to serve as a vertical and horizontal measuring point. Any site clearing that may be necessary for equipment access, as well as arrangement of utility clearances prior to intrusive activities, will be coordinated with NASA (Section 3.4).

3.1 Surface Water and Sediment Sampling

A surface water and sediment sampling effort will be conducted at WWTP1, WWTP3, AP1, and AP3 AOCs. A total of four sediment and four collocated surface water samples will be collected from WWTP1, three sediment and three surface water samples from WWTP3, one sediment and

one surface water sample from AP1, and two sediment and three collocated surface water samples from AP3. Analytical parameters will vary between sediment and surface water samples and between the AOCs. Tables 3-1 through 3-4 summarize the samples, analytical parameters, and holding times of the sediment and surface water that will be collected at each AOC. Note that the number of sediment samples collected and the analyses run on each of these samples is partially influenced by the sampling and analytical protocol performed during the respective SIs.

Sediment and surface water (if present) samples will be collected at approximately the same locations sampled during the 1997 SI. Sediment samples will be collected from a depth of 0 to 6 inches if sediment is present at this depth. Sample collection depth will be recorded on the sample collection log. Surface water samples will be collocated with the sediment sample location if surface water is present. 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, and this alternative location will be recorded on the sample collection log.

3.2 Groundwater Remedial Investigation

As noted in Section 3.0, Phase 2 groundwater investigation activities are based upon the analytical results of groundwater and soil analytical results collected during Phase 1. During Phase 1, temporary piezometers were installed and soil borings were drilled at 1997 SI locations, former suspected spill or possible contaminant locations, and downgradient areas. Based on the analytical results and groundwater flow patterns of the piezometer samples, monitoring wells will be installed in the overburden/shale and underlying limestone formation. Groundwater from each monitoring well will be sampled using the low-flow technique described in Section 3.2.6, unless the Ohio Environmental Protection Agency (OEPA) and USACE approve a variation. Tables 3-1 through 3-4 summarize the groundwater samples and analytical parameters, and Figures 3-1 through 3-4 show the proposed Phase 1 and historical SI sampling locations.

3.2.1 Monitoring Well Locations

A total of 24 wells will be installed at WWTP1, WWTP3, AP1, and AP3, based on the analytical results of the soil boring/piezometer samples. Three overburden/shale and three limestone bedrock monitoring wells are proposed to be installed at each of the sites. The specific location of each well will be determined by the geologist/geotechnical engineer with consultation of the USACE, based on the analytical results of the piezometer samples. Total depths of the overburden/shale and bedrock wells were estimated at each of the AOCs, based on well construction information from existing wells in the area. The geologist/geotechnical engineer

will visually classify and log all borehole material according to the Unified Soil Classification System (USCS) and USACE Engineer Manual EM-1110-1-4000 (USACE, 1998).

Although unexpected, if raw explosive material is encountered during soil (or groundwater) sampling, all activities will stop, and USACE will be contacted to discuss procedures for disposal.

3.2.2 Monitoring Well Installation and Development

3.2.2.1 Monitoring Well Installation

The geologist/geotechnical engineer will schedule and coordinate the location of all underground utilities in the vicinity of the borehole site prior to drilling activities. Two mobilizations are assumed for activities related to well installation.

As noted in Section 3.1, the estimated depth for each of the new overburden/shale and limestone bedrock wells vary depending on the AOC location. Listed below are estimates of the total well depth based upon nearby existing wells:

WWTP1	Overburden/shale wells	20 feet
	Limestone bedrock wells	80 feet
WWTP3	Overburden/shale wells	15 feet
	Limestone bedrock wells	75 feet
AP1	Overburden/shale wells	25 feet
	Limestone bedrock wells	85 feet
AP3	Overburden/shale wells	15 feet
	Limestone bedrock wells	75 feet

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* (USACE, 1998) and applicable state regulations and requirements, including Ohio Administrative Code 3745-9-03, *Monitoring Well*. Limestone bedrock wells are anticipated to be installed as double cased wells as described in Section 3-10 of EM 1110-1-4000 (USACE, 1998). A well log will be

completed and filed on line with the Ohio Department of Natural Resources (http://www.dnr.state.oh.us/water/maptechs/submitlogs/).

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

Three overburden/shale and three limestone bedrock monitoring wells will be installed at each AOC. Borings for overburden/shale monitoring wells will be advanced 7 to 8 feet past the depth groundwater is encountered or until bedrock using hollow-stem auger drilling methods or other appropriate drilling methods. Two-inch inside diameter polyvinyl chloride (PVC) well material consisting of a 10-foot-long screen and riser will be installed into the borehole. A filter pack will be tremied into the borehole to surround the screen and brought to a height of approximately 2 feet above the screen top. An approximate 2- to 5-foot bentonite seal will be tremied to depth above the filter pack and allowed to hydrate for at least 1 hour. A neat cement/bentonite mixture (95 percent Type II or V portland cement and 5 percent bentonite powder mixed with 5 to 7 gallons clean water) will be placed from the bentonite seal to approximately 3 feet below grade.

The limestone bedrock monitoring wells will be 2-inch diameter and double cased. A pilot borehole for each well will be drilled until auger refusal using 4 l/4-inch hollow stem augers, and the borehole will be overdrilled using 8 l/4-inch hollow stem augers. Five feet of competent bedrock will be drilled within the augers using an 8-inch-outside diameter (OD) roller cone bit to allow for the installation of low-carbon steel isolation casing. The steel isolation casing will be pressure grouted in place, and the grout will be allowed to cure for at least 48 hours. Limestone bedrock borings will completed using a rock core bit, cutting a maximum 6-inch-OD borehole and a rock core tube measuring 5 feet in length. If a 6-inch-OD rock bit is not used during bedrock drilling, the borehole will be reamed with a rotary bit to attain a 6-inch-OD diameter borehole after reaching the desired depth for monitoring well installation. This will allow a total of 4 inches of filter pack material to surround the 2-inch-diameter screen placed in the borehole for the monitoring well. Upon removal of the rock core tube, measurement of the rock recovered compared to the run length (length of the bedrock drilled) will be performed. If the rock core length does not match the run length, total depth of the borehole will be measured to determine if

the rock core was lost or washed way. Mention of the lost core will be made on the borelog. Fractures (mechanical, natural, or healed) will also be included on the borelog.

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

Construction of the limestone bedrock wells will follow the same requirements as the overburden/shale wells. Requirements are listed in EM 1110-1-4000 (USACE, 1998). Typical monitoring well installation and construction diagrams are included in the SWSAP (Shaw, 2008b). All monitoring well drill cuttings will be drummed, labeled, and handled as described in Chapter 6.0.

3.2.2.2 Monitoring Well Development

Each monitoring well will be developed using a submersible pump or bailer as soon as practical, but no sooner than 48 hours nor longer than 7 calendar days after the placement of the internal mortar collar around the well. Prior to development, the static water level will be measured from the top of the casing and recorded. Static water levels will also be measured 24 hours after development. The well will be developed until discharging water is clear to the unaided eye and the sediment thickness remaining in the well is less than 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, turbidity, specific conductance, and temperature will be made, and descriptions of the development technique and the physical characteristics of the water (clarity, color, turbidity, and odor) will be recorded by the geologist/geotechnical engineer. Wells will be developed by pumping, bailing, and surging without using acids, flocculants, disinfectants, or dispersing agents. All purged water will be drummed at the well site. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well. The development procedure will continue until the following conditions are met:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- Thickness of the accumulated sediment in the well is less than 1 percent of the length of the well screen.
- Temperature, pH, 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 from the potable source 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 camera. The photograph will be submitted as part of the well development log. The photograph will be a suitably back-lit closeup to show the clarity of the water. 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, turbidity, 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.

3.2.3 Water Level Monitoring

The water elevations of each monitoring well located at the AOC will be measured at once and prior to purging the first well (Section 3.2.5). Water levels of the piezometers installed as part of Phase 1 RI activities 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 AOC. The depth to water will be measured to the nearest 0.01 foot from the northern edge of the riser (inner casing). Note that the piezometers will be abandoned after this measurement, as described in Section 3.4. Therefore, the water levels of only the monitoring wells will be measured as part of the second monitoring well sampling event.

3.2.4 Monitoring Well Samples

Two rounds of groundwater samples will be collected from each of the 24 new monitoring wells at different times of the year (e.g., spring and fall) to allow for seasonal differences. One round will be conducted during the dry season (expected May 2008) and the second during the wet season (October or November 2008). Each monitoring well will be sampled using a low-flow groundwater sampling technique (Section 3.2.6) and analyzed for target compound list (TCL) VOCs, TCL SVOCs, nitroaromatics, target analyte list (TAL) dissolved (filtered) metals, TAL total (unfiltered) metals, and water quality parameters turbidity, alkalinity, hardness, total dissolved solids, total suspended solids, chloride, total cyanide, nitrate, sulfate, and ferrous iron. 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.

3.2.5 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.

3.2.6 Groundwater Sampling Methodology and Procedures

The monitoring wells will be purged and sampled a minimum of 14 days after development (Section 3.2.2), 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 at the subject site 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.

Two procedures are available for purging and sampling wells: low-flow (minimal drawdown) and bailing. Low-flow is the preferred purging method where adequate recharge exists. If wells 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 will be checked for proper identification and structural integrity.
- After unlocking the well 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 site-wide 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 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 prepumping (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 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 four hours of purging, Shaw will notify USACE and discuss a plan for sampling the well. 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.

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

- The order in which groundwater samples will be collected will be 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 so 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 paragraphs. The geologist/geotechnical engineer will coordinate with the primary and QA laboratories as to the volumes of sample necessary to satisfy all internal laboratory QC requirements. All samples will be collected and analyzed in conformance with applicable EPA and USACE requirements, using techniques and equipment described herein and in the SWSAP (Shaw, 2008b).

3.3 Land Surveying

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

3.4 Utility Clearances

Prior to beginning any intrusive investigation (i.e., soil boring drilling), 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. After NASA has located underground utilities that may be present in the AOCs, all boring locations will be hand dug, probed with an air or water knife, or screened with geophysical instrumentation to a depth of 5 feet before drilling begins.

3.5 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 a 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 U.S. citizens.

3.6 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 USACE. Well abandonment procedures will follow the USACE guidelines and will be in accordance with OEPA and Ohio Department of Natural Resource 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*. 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 (if present) and PVC well material will be cut approximately 3 feet below ground surface.

- A concrete/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 Numbering System

The sample numbering system to be used during this investigation will conform to 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	09	XX	XXXX	XXXX	XXXX	(XXXX)

[a]Sample type:

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

[b]Site:

WWTP 1 – Waste Water Treatment Plant 1
WWTP 3 – Waste Water Treatment Plant 3
Ash Pit 1 – Ash Pit 1
Ash Pit 3 – Ash Pit 3

[c]Depth: Only required for soil samples.

The complete sample number will be recorded by the Shaw field geologist in the field activity daily log and/or in the boring log, and in the sample collection log as appropriate. PBOW-00-SB-WWTP1-SO001-AB0001-08-10 signifies that this soil sample was collected from a depth of 8 to 10 feet at soil location SO001 in WWTP1 with a sample number of AB0001 (Shaw, 2008b).

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. Tables 3-1 through 3-4 summarize the analytical parameters required and associated laboratory methods to be used during this investigation.

A contract laboratory will analyze samples for TCL VOCs, nitroaromatics, TCL SVOCs, TAL metals (filtered and unfiltered), and water quality parameters turbidity, alkalinity, hardness, total dissolved solids, total suspended solids, chloride, total cyanide, nitrate, and sulfate. All applicable analyses will meet the recommended method guidance found in *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition Update (EPA, 1996) and its subsequent updates. They will meet the QA/QC requirements outlined in 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, 2008b) 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. Water and rinse water will be managed for disposal as described in Section 6.2. 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 does not contact analytical samples):

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

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

- Wash and scrub using a brush with nonphosphate detergent.
- Rinse with potable water.
- Rinse with American Society for Testing and Materials (ASTM) Type II water.
- Rinse with isopropanol (when sampling for metals).
- Rinse with 10 percent nitric acid (glass and Teflon or Teflon-lined material)
- 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.

5.0 Sample Preservation, Packing, and Shipping

Sample containers and caps will be new, certified as precleaned, and made of materials recommended by the 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 maintained, as described in Chapter 6.0 of the SWSAP. Samples will be cooled to a temperature of approximately $4^{o}C$ 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 airbill 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 and rock (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, 2008b). Tables 3-1 through 3-4 also detail soil and groundwater IDW sample collection for each AOC. The following is a brief summary of the procedures for handling IDW.

6.1 Soil and Groundwater

Residual subsurface soil and water 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 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. 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 for VOCs, SVOCs, and metals. In addition, hazardous waste characteristic parameters ignitability, corrosivity, and reactivity will be analyzed. Seven-day turnaround time will be used, unless otherwise directed by the project manager.

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

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

7.0 References

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U.S. Army Corps of Engineers (USACE), 2000b, ***Final Report, Limited Site Investigation for the former Plum Brook Ordnance Works, Ash Pits No. 1 and 3, July.***

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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, Office of Emergency and Remedial Response***, Washington, D.C. OSWER Directive 9355.9-0), EPA 540-R-93-071.

TABLES

Table 2-1

Summary of Data Quality Objectives
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
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 groundwater and soil.	Contaminant Source Production of TNT, DNT, and pentolite. Past DOD operations. Migration Pathways Soil, sediment, surface water, and groundwater. Potential receptors Wildlife, human. Potential Contaminants of Concern SVOCs, metals, PCBs, and explosives.	Groundwater Surface Water Sediments Soil	Determine if there are hazardous substances present that constitute an unacceptable risk to human health and the environment. Define site physical features and characteristics. Evaluate fate and transport pathways. Determine the nature and extent of source areas. Define current and future routes of exposure. Determine whether contaminant distribution is consistent with DOD activities.	Groundwater Metals Explosives SVOCs Water quality parameters[a] Surface Water SVOCs Explosives Metals Hardness Sediments 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.
SVOC - Semivolatile organic compound.
TNT - Trinitrotoluene.
Shaw - Shaw Environmental, Inc.
TOC - Total organic carbon.
PCB - Polychlorinated biphenyls.

[a]Water quality parameters include turbidity, alkalinity, hardness, total dissolved and suspended soilds, chloride, total cyandide, nitrite, oxidation-reduction potential, sulfate, and ferrous iron.

Table 2-2

Summary of Analytical Samples
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sediment Samples [a]						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	6	1	1	NA	NA	1/1
TCL SVOCs	3	1	1	NA	NA	1/1
PCBs	12	2	1	NA	NA	1/1
TAL Metals	3	1	1	NA	NA	1/1
Total Organic Carbon	4	NA	NA	NA	NA	1/1
Surface Water Samples [a]						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	12	2	1	NA	NA	1/1
TCL SVOCs	8	1	1	NA	NA	1/1
TAL Metals	8	1	1	NA	NA	1/1
Monitoring Well Samples [a,b]						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	48	6	2	2	NA	4/4
TCL VOCs	48	6	2	2	6	4/4
TCL SVOCs	48	6	2	2	NA	4/4
Metals (Filtered)	48	6	2	2	NA	4/4
Metals (Total)	48	6	2	2	NA	4/4
Water Quality Parameters [a]	48	NA	NA	NA	NA	4/4

[a] Refer to Tables 3-1 through 3-4 and footnotes for groundwater quality parameters.
[b] Two rounds of sampling from a total of 24 new wells.

NA - Not applicable.
PCB - Polychlorinated biphenyl.
QA - Quality assurance.
QC - Quality control.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
VOC - Volatile organic compound.

Table 3-1

Summary of Surface Water, Sediment, and Groundwater Analytical Samples at WWTP1
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Number of Samples to be Collected	Analytical Parameters[a]	Analytical Method[b]
Sediments	1	PCBs	SW-846 3541/8082
		Total Organic Carbon	Walkley-Black
	3	PCBs	SW-846 3541/8082
Surface water	4	TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
Groundwater	6	TCL Volatiles	SW-846 8260B
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		Total TAL Metals	SW-846 3005A/6010B/7470A
		Dissolved TAL Metals	SW-846 3005A/6010B/7470A
		Turbidity[c]	MCAWW 180.1
		Alkalinity[c]	MCAWW 310.1
		Hardness[c]	MCAWW 130.2
		Total Dissolved Solids[c]	MCAWW 160.1
		Total Suspended Solids[c]	MCAWW 160.2
		Chloride[c]	MCAWW 325.3
		Cyanide, total[c]	SW-846 9010A/9012
		Nitrate[c]	MCAWW 352.1
		Oxidation-reduction potential[c]	[d]
		Sulfate[c]	MCAWW 375.3
		Ferrous iron[c]	Hach test kit
Groundwater IDW	1	TCL VOCs	SW-846 5030B/8260B
		TCL SVOCs	SW-846 3510C/8270C
		Nitroaromatics	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
		Ignitability	SW-846 1010
		pH	SW-846 9045B
		Corrosivity	SW-846 1110
		Reactive Cyanide	7.3.3/7.3.4
		Reactive Sulfide	7.3.3/7.3.4
Soil IDW	1	TCLP VOCs	SW-846 1311/5030B/8260B
		TCLP SVOCs	SW-846 1311/3510C/8270C
		TCLP Metals	SW-846 1311/3010A/6010B/7470A
		Ignitability	SW-846 1010
		Corrosivity	SW-846 1110
		Reactivity	7.3.3.2/7.3.4.2

[a]TAL and TCL are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages.

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

[c]Water quality parameter.

[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020:*Method for Chemical Analysis of Water and Wastes* in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, USEPA Publication, Third Edition.

IDW - Investigation-derived waste.
PBC - Polychlorinated biphenyl.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TCLP - Toxicity characteristic leaching procedure.
VOC - Volatile organic compound.

Table 3-2

Summary of Surface Water, Sediment, and Groundwater Analytical Samples at AP 1
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Number of Samples to be Collected	Analytical Parameters[a]	Analytical Method[b]
Sediments	1	Nitroaromatic Compounds	SW-846 8330
		TAL Metals	SW-846 3005A/6010B/7470A
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		PCBs	SW-846 3541/8082
		Total Organic Carbon	Walkley-Black
	1	PCBs	SW-846 3541/8082
		Nitroaromatic Compounds	SW-846 8330
Surface water	1	Nitroaromatic Compounds	SW-846 3535/8330
	1	Nitroaromatic Compounds	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
Groundwater	6	TCL Volatiles	SW-846 8260B
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		Total TAL Metals	SW-846 3005A/6010B/7470A
		Dissolved TAL Metals	SW-846 3005A/6010B/7470A
		Turbidity[c]	MCAWW 180.1
		Alkalinity[c]	MCAWW 310.1
		Hardness[c]	MCAWW 130.2
		Total Dissolved Solids[c]	MCAWW 160.1
		Total Suspended Solids[c]	MCAWW 160.2
		Chloride[c]	MCAWW 325.3
		Cyanide, total[c]	SW-846 9010A/9012
		Nitrate[c]	MCAWW 352.1
		Oxidation-reduction potential[c]	[d]
		Sulfate[c]	MCAWW 375.3
		Ferrous iron[c]	Hach test kit
Groundwater IDW	1	TCL VOCs	SW-846 5030B/8260B
		TCL SVOCs	SW-846 3510C/8270C
		Nitroaromatics	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
		Ignitability	SW-846 1010
		pH	SW-846 9045B
		Corrosivity	SW-846 1110
		Reactive Cyanide	7.3.3/7.3.4
		Reactive Sulfide	7.3.3/7.3.4
Soil IDW	1	TCLP VOCs	SW-846 1311/5030B/8260B
		TCLP SVOCs	SW-846 1311/3510C/8270C
		TCLP Metals	SW-846 1311/3010A/6010B/7470A
		Ignitability	SW-846 1010
		Corrosivity	SW-846 1110
		Reactivity	7.3.3.2/7.3.4.2

[a]TAL and TCL are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages.
[b]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition and *Methods for Chemical Analysis of Water and Wastes* , EPA-600/4-79-020, March 1983 and subsequent revisions.
[c]Water quality parameter.
[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020: *Method for Chemical Analysis of Water and Wastes* in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* , USEPA Publication, Third Edition.

IDW - Investigation-derived waste.
PBC - Polychlorinated biphenyl.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TCLP - Toxicity characteristic leaching procedure.
VOC - Volatile organic compound.

Table 3-3

Summary of Surface Water, Sediment, and Groundwater Analytical Samples at WWTP 3
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Number of Samples to be Collected	Analytical Parameters[a]	Analytical Method[b]
Sediments	1	Nitroaromatic Compounds	SW-846 8330
		TAL Metals	SW-846 3005A/6010B/7470A
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		PCBs	SW-846 3541/8082
		Total Organic Carbon	Walkley-Black
	2	PCBs	SW-846 3541/8082
Surface water	3	TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
Groundwater	6	TCL Volatiles	SW-846 8260B
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		Total TAL Metals	SW-846 3005A/6010B/7470A
		Dissolved TAL Metals	SW-846 3005A/6010B/7470A
		Turbidity[c]	MCAWW 180.1
		Alkalinity[c]	MCAWW 310.1
		Hardness[c]	MCAWW 130.2
		Total Dissolved Solids[c]	MCAWW 160.1
		Total Suspended Solids[c]	MCAWW 160.2
		Chloride[c]	MCAWW 325.3
		Cyanide, total[c]	SW-846 9010A/9012
		Nitrate[c]	MCAWW 352.1
		Oxidation-reduction potential[c]	[d]
		Sulfate[c]	MCAWW 375.3
		Ferrous iron[c]	Hach test kit
Groundwater IDW	1	TCL VOCs	SW-846 5030B/8260B
		TCL SVOCs	SW-846 3510C/8270C
		Nitroaromatics	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
		Ignitability	SW-846 1010
		pH	SW-846 9045B
		Corrosivity	SW-846 1110
		Reactive Cyanide	7.3.3/7.3.4
		Reactive Sulfide	7.3.3/7.3.4
Soil IDW	1	TCLP VOCs	SW-846 1311/5030B/8260B
		TCLP SVOCs	SW-846 1311/3510C/8270C
		TCLP Metals	SW-846 1311/3010A/6010B/7470A
		Ignitability	SW-846 1010
		Corrosivity	SW-846 1110
		Reactivity	7.3.3.2/7.3.4.2

[a]TAL and TCL are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages.
[b]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition and *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, March 1983 and subsequent revisions.
[c]Water quality parameter.
[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020: *Method for Chemical Analysis of Water and Wastes* in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, USEPA Publication, Third Edition.

IDW - Investigation-derived waste.
PBC - Polychlorinated biphenyl.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TCLP - Toxicity characteristic leaching procedure.
VOC - Volatile organic compound.

Table 3-4

Summary of Surface Water, Sediment, and Groundwater Analytical Samples at AP3
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Number of Samples to be Collected	Analytical Parameters[a]	Analytical Method[b]
Sediments	1	Nitroaromatic Compounds	SW-846 8330
		TAL Metals	SW-846 3005A/6010B/7470A
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		PCBs	SW-846 3541/8082
		Total Organic Carbon	Walkley-Black
	2	PCBs	SW-846 3541/8082
		Nitroaromatic Compounds	SW-846 8330
Surface water	3	Nitroaromatic Compounds	SW-846 3535/8330
Groundwater	6	TCL Volatiles	SW-846 8260B
		TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
		Nitroaromatic Compounds	SW-846 3535/8330
		Total TAL Metals	SW-846 3005A/6010B/7470A
		Dissolved TAL Metals	SW-846 3005A/6010B/7470A
		Turbidity[c]	MCAWW 180.1
		Alkalinity[c]	MCAWW 310.1
		Hardness[c]	MCAWW 130.2
		Total Dissolved Solids[c]	MCAWW 160.1
		Total Suspended Solids[c]	MCAWW 160.2
		Chloride[c]	MCAWW 325.3
		Cyanide, total[c]	SW-846 9010A/9012
		Nitrate[c]	MCAWW 352.1
		Oxidation-reduction potential[c]	[d]
		Sulfate[c]	MCAWW 375.3
		Ferrous iron[c]	Hach test kit
Groundwater IDW	1	TCL VOCs	SW-846 5030B/8260B
		TCL SVOCs	SW-846 3510C/8270C
		Nitroaromatics	SW-846 3535/8330
		TAL Metals	SW-846 3005A/6010B/7470A
		Ignitability	SW-846 1010
		pH	SW-846 9045B
		Corrosivity	SW-846 1110
		Reactive Cyanide	7.3.3/7.3.4
		Reactive Sulfide	7.3.3/7.3.4
Soil IDW	1	TCLP VOCs	SW-846 1311/5030B/8260B
		TCLP SVOCs	SW-846 1311/3510C/8270C
		TCLP Metals	SW-846 1311/3010A/6010B/7470A
		Ignitability	SW-846 1010
		Corrosivity	SW-846 1110
		Reactivity	7.3.3.2/7.3.4.2

[a]TAL and TCL are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages.
[b]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition and *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, March 1983 and subsequent revisions.
[c]Water quality parameter.
[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020: *Method for Chemical Analysis of Water and Wastes* in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, USEPA Publication, Third Edition.

IDW - Investigation-derived waste.
PBC - Polychlorinated biphenyl.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TCLP - Toxicity characteristic leaching procedure.
VOC - Volatile organic compound.

Table 5-1

Analytical Methods, Containers, Preservatives, and Holding Times
Phase 2 Remedial Investigation
Waste Water Treatment Plans 1 and 3/Ash Pits 1 and 3
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 3520C/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 (Total/Dissolved)	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[a]	MCAWW 180.1	(1) 250 mL HDPE	Cool to 4°C	48 Hours
	Alkalinity[a]	MCAWW 310.1		Cool to 4°C	14 days
	Hardness[a]	MCAWW 130.2	(1) 250 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
	Total Disolved Solids[a]	MCAWW 160.1	(1) 500 mL HDPE	Cool to 4°C	7 days
	Total Suspended Solids[a]	MCAWW 160.2		Cool to 4°C	7 days
	Chloride[a]	MCAWW 325.3	(1) 250 mL HDPE	Cool to 4°C	28 days
	Cyanide, Total[a]	SW-846 9010A/9012	(1) 250 mL HDPE	Cool to 4°C, NaOH to pH >12	14 days
	Nitrate[a]	MCAWW 352.1	(1) 250 mL HDPE	Cool to 4°C	48 Hours
	Sulfate[a]	MCAWW 375.3	(1) 250 mL HDPE	Cool to 4°C	28 days
	Ferrous Iron[a]	Hach Test Kit (in field)	None	None	None
Surface water	TCL SVOCs	SW-846 3520C/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 (Total/Dissolved)	SW-846 3005A/6010B/7470A	(1) 100 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
Sediments	TCL SVOCs	SW-846 3541/8270C	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction/40 days
	Nitroaromatics	SW-846 8330			14 days extraction/40 days
	PCBs	SW-846 3541/8082			14 days extraction/40 days
	TAL Metals	SW-846 3050B/6010B/7471A			6 months (28 days for Hg)
	TOC	Walkley-Black			28 days

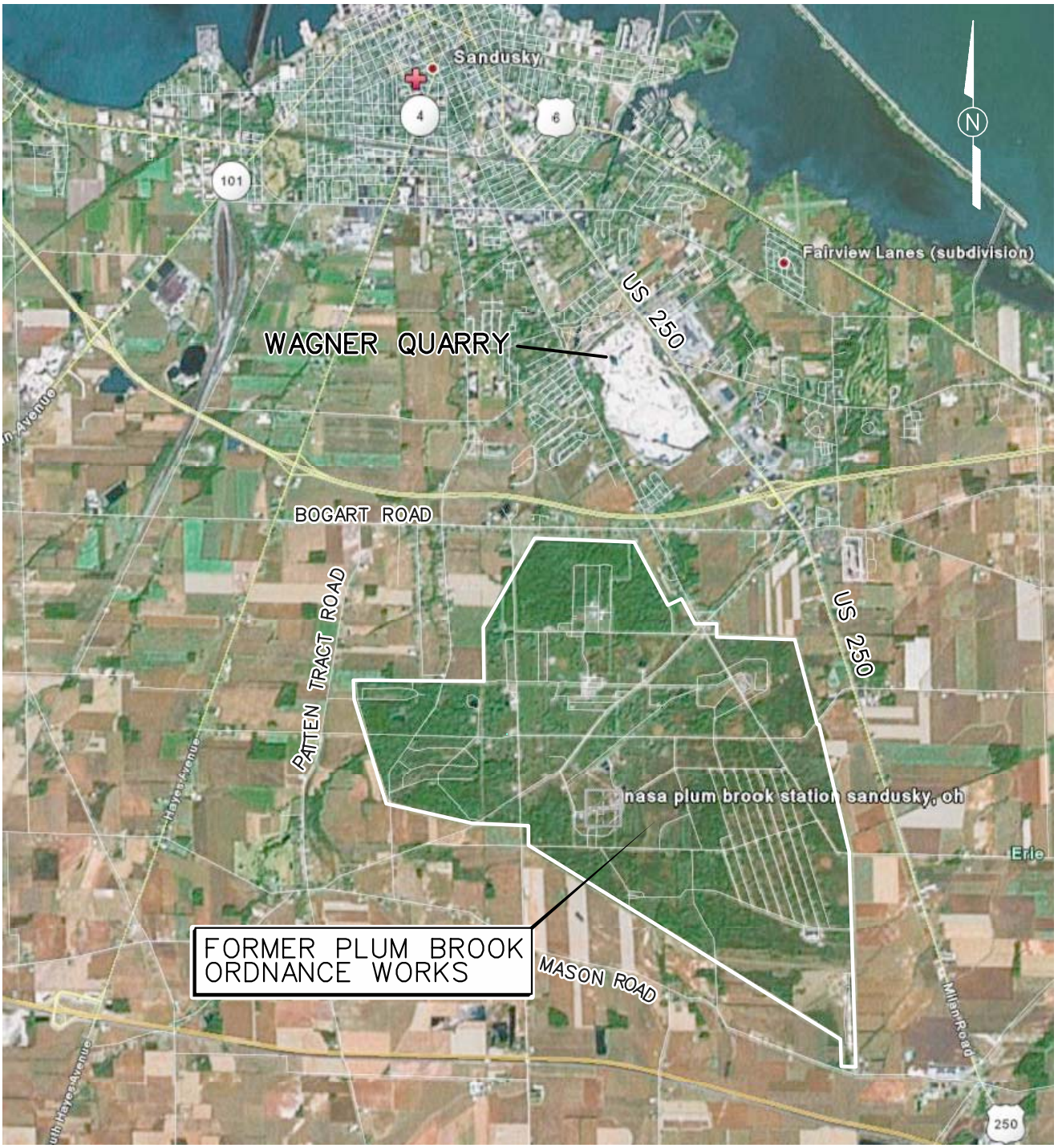
Table 5-1

Analytical Methods, Containers, Preservatives, and Holding Times
Phase 2 Remedial Investigation
Waste Water Treatment Plans 1 and 3/Ash Pits 1 and 3
Former Plum Brook Ordnance Works, Sandusky Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater 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			
Soil 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 1311/3010A/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

^{o}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.
NaOH - Sodium hydroxide.
PAH - Polynuclear aromatic hydrocarbon.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TOC - Total organic compound.
VOC - Volatile organic compound.
IDW - Investigative-derived waste.
EPA - U.S. Environmental Protection Agency.
VOA - Volatile organic analysis.
OZ - Ounces.
Ext. - Extraction
ASAP - As soon as possible.
*Number of containers required in parentheses.
[a]Water quality parameter.

FIGURES



NOT TO SCALE

FIGURE 1-1
PBOW VICINITY MAP

PHASE 2 WWTP1 &3 AND AP1 &3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 11/10/08	DATE LAST REV.:	DRAFT. CHCK. BY:	INITIATOR: D. KESSLER
DRAWN BY: C. BENTLEY	DRAWN BY:	ENGR. CHCK. BY:	PROJ. MGR.: S. DOWNEY

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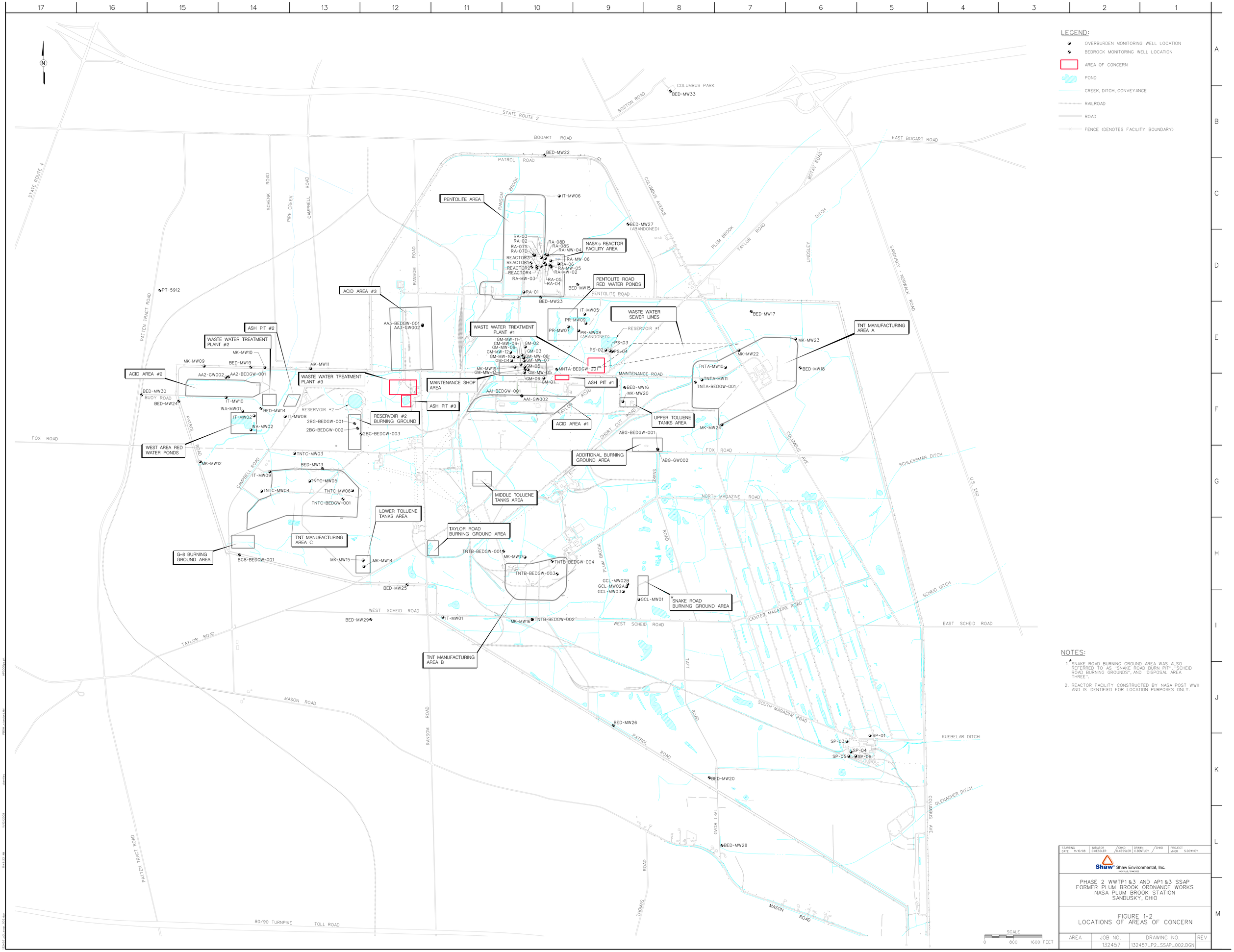

NOTES:

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 11/10/08	INITIATOR D.KESSLER	CHKD D.KESSLER	DRAWN C.BENTLEY	CHKD	PROJECT MNGR S.DOWNEY

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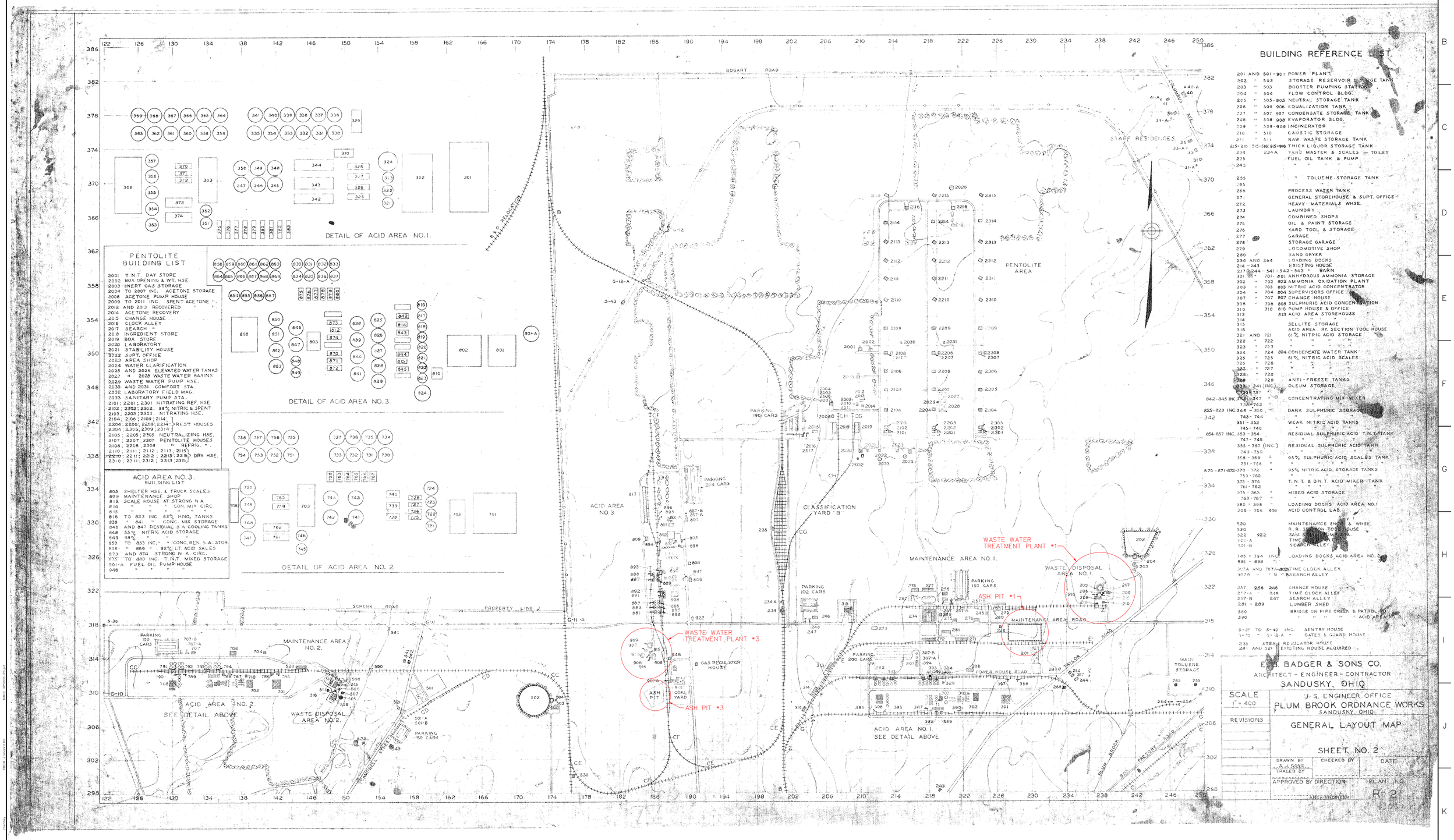
PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN

AREA	JOB NO.	DRAWING NO.	REV
	132457	132457_P2_SSAP_002.DGN	



REFERENCE: E.B. BADGER & SONS CO.

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/10/08	KESSLER	KESSLER	BENTLEY		S.DOWNEY

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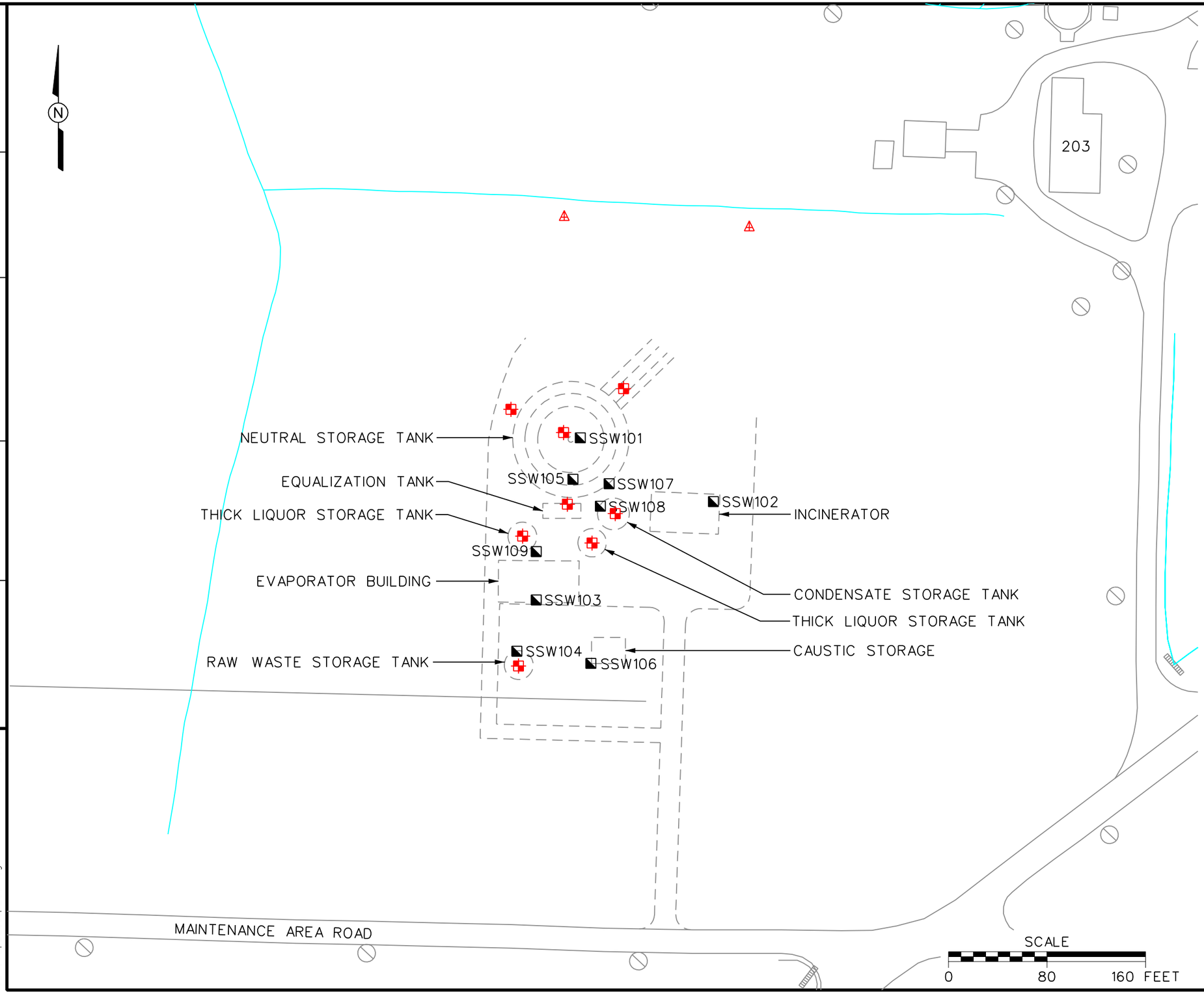
KNOXVILLE, TENNESSEE

PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 1-3
LOCATIONS OF WASTE WATER TREATMENT PLANTS NOs. 1 & 3 AND ASH PITS NOs. 1 & 3

AREA	JOB NO.	DRAWING NO.	REV
	132457	132457_P2_SSAP_003.DGN	



LEGEND:

- PREVIOUS SURFACE SOIL SAMPLE (USACE, 2000)
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER

NOTES:

1. SOIL SAMPLED PREVIOUSLY IN 1999 (U.S. ARMY CORPS OF ENGINEERS [USACE], 2000 LIMITED SITE INVESTIGATION, FINAL REPORT, FOR THE FORMER PLUM BROOK ORDNANCE WORKS WASTE WATER TREATMENT PLANTS NO. 1 AND 3, SANDUSKY, OHIO, JULY).
2. PROPOSED LOCATIONS MAY BE MOVED BASED ON FIELD OBSERVATIONS.
3. ADDITIONAL PIEZOMETERS WILL BE COMPLETED AT 4 OF THE PROPOSED SOIL BORING LOCATIONS BASED ON FIELD OBSERVATIONS.
4. THREE OVERBURDEN/SHALE AND THREE LIMESTONE BEDROCK MONITORING WELLS WILL BE LOCATED PENDING REVIEW OF SOIL BORING/PIEZOMETER ANALYTICAL RESULTS.

FIGURE 3-1

WWTP1 - PHASE 1 PROPOSED SOIL BORING AND TEMPORARY PIEZOMETER LOCATIONS

PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DRAFT. CHCK. BY: C. BENTLEY	INITIATOR: D. KESSLER	132457_p2_ssap_004.dgn	
ENGR. CHCK. BY: T. SIARD	PROJ. MGR.: S. DOWNEY	PROJ. NO.: 132457	
STARTING DATE: 11/10/08	DATE LAST REV.:		
DRAWN BY: C. BENTLEY	DRAWN BY:		

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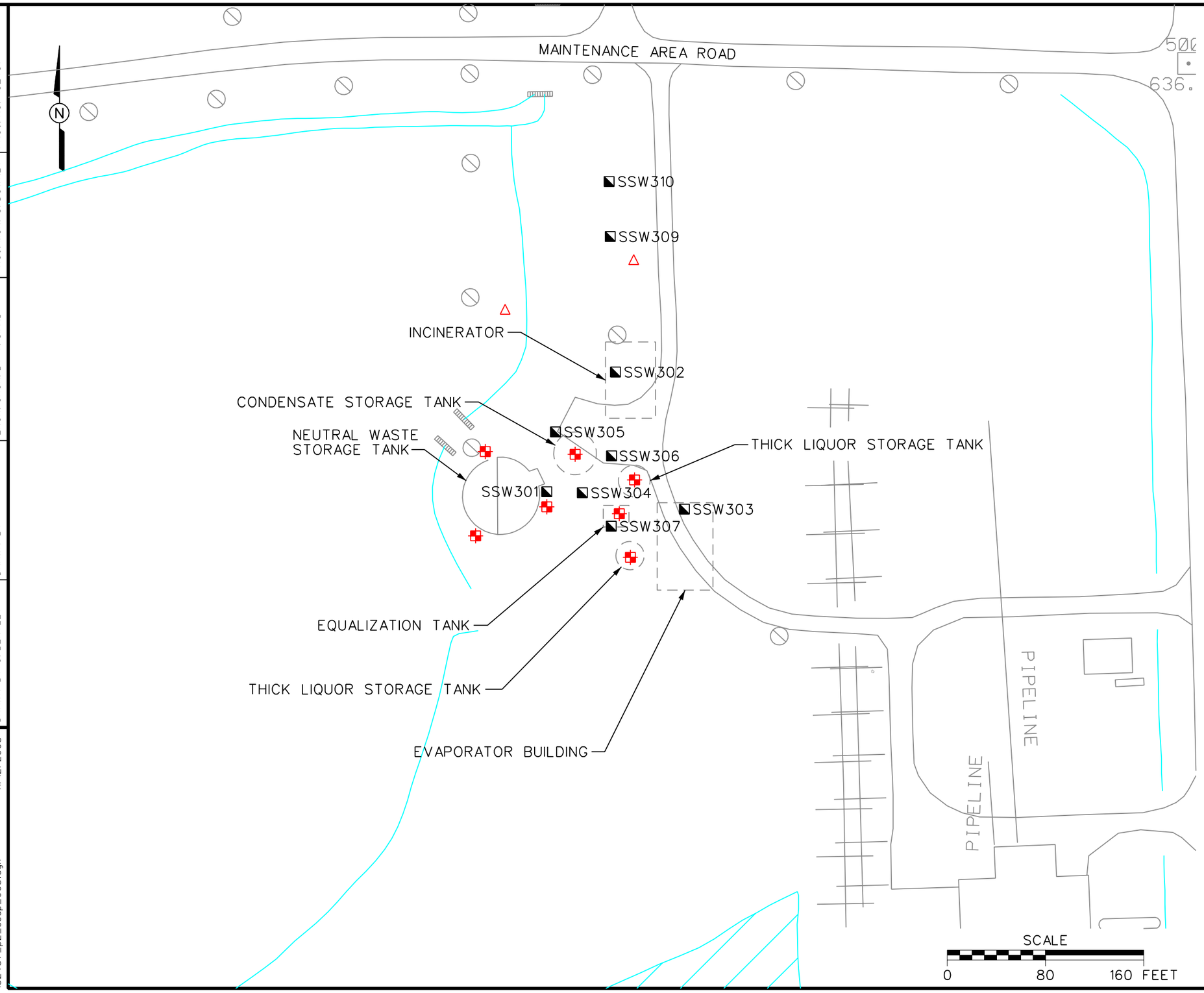

LEGEND:

- PREVIOUS SURFACE SOIL SAMPLE (APPROXIMATE) (USACE, 2000)
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER
- PROPOSED PIEZOMETER

NOTES:

1. SOIL SAMPLED PREVIOUSLY IN 1999 (U.S. ARMY CORPS OF ENGINEERS [USACE], 2000 LIMITED SITE INVESTIGATION, FINAL REPORT, FOR THE FORMER PLUM BROOK ORDNANCE WORKS WASTE WATER TREATMENT PLANTS NO. 1 AND 3, SANDUSKY, OHIO, JULY).
2. PROPOSED LOCATIONS MAY BE MOVED BASED ON FIELD OBSERVATIONS.
3. ONE ADDITIONAL SOIL BORING WILL BE COMPLETED BASED ON FIELD OBSERVATIONS.
4. ADDITIONAL PIEZOMETERS WILL BE COMPLETED AT 4 OF THE PROPOSED SOIL BORING LOCATIONS BASED ON FIELD OBSERVATIONS.
5. THREE OVERBURDEN/SHALE AND THREE LIMESTONE BEDROCK MONITORING WELLS WILL BE LOCATED PENDING REVIEW OF SOIL BORING/PIEZOMETER ANALYTICAL RESULTS.

FIGURE 3-2
WWTP3 - PHASE 1 PROPOSED SOIL BORING AND TEMPORARY PIEZOMETER LOCATIONS

PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

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STARTING DATE: 11/10/08	DRAWN BY: C. BENTLEY
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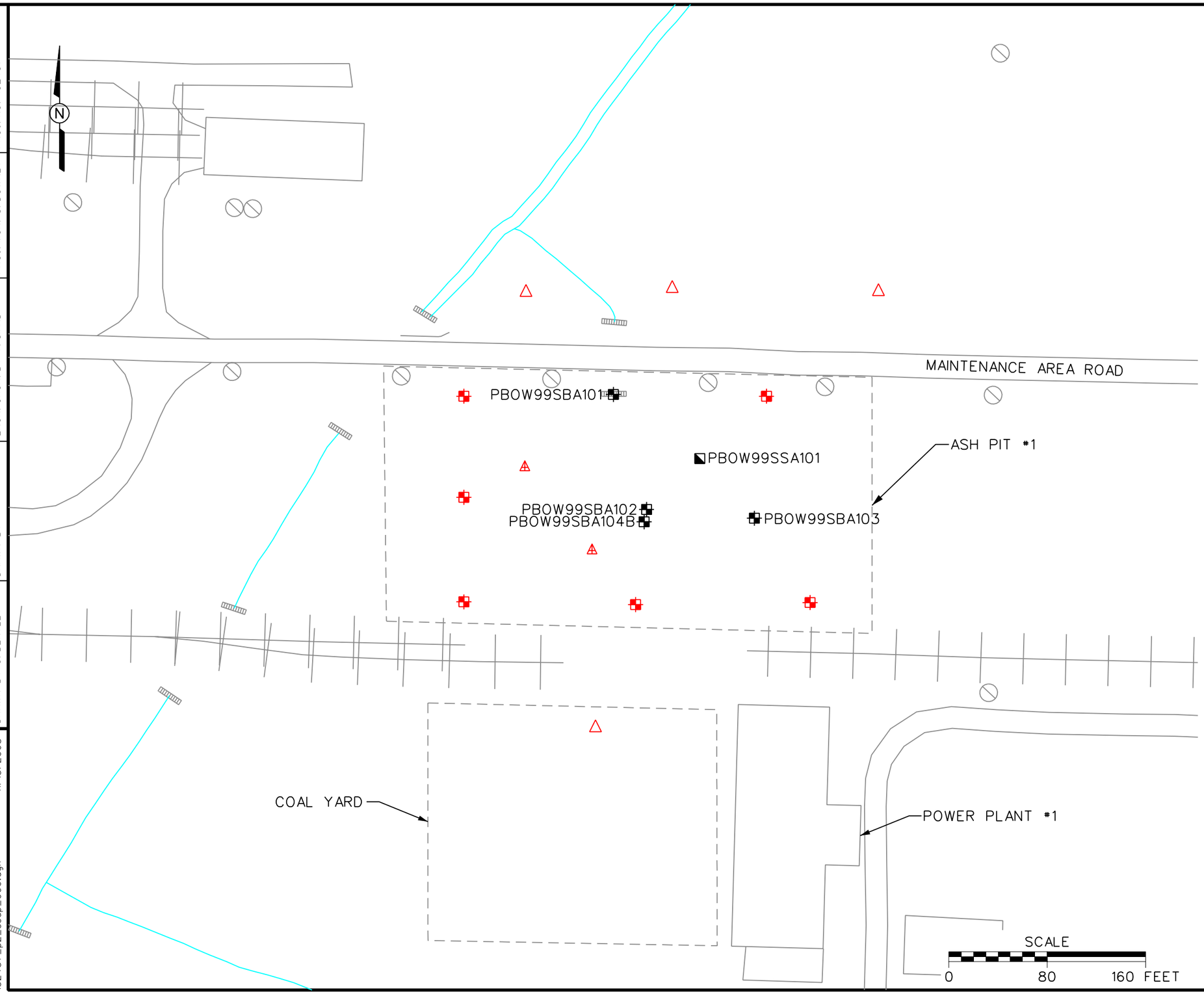

LEGEND:

- PREVIOUS SOIL BORING (USACE, 2000)
- PREVIOUS SURFACE SOIL SAMPLE (USACE, 2000)
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER
- PROPOSED PIEZOMETER

NOTES:

1. PROPOSED LOCATIONS MAY BE MOVED BASED ON FIELD OBSERVATIONS.
2. PREVIOUS SOIL SAMPLES COLLECTED IN 1999 (USACE, 2000, LIMITED SITE INVESTIGATION, FINAL REPORT, FOR THE FORMER PLUM BROOK ORDNANCE WORKS ASH PITS NO. 1 AND 3, SANDUSKY, OHIO, JULY).
3. SOIL BORING PLACEMENT IN ASH PIT BASED ON HISTORIC PHOTOGRAPH.
4. THREE OVERBURDEN/SHALE AND THREE LIMESTONE BEDROCK MONITORING WELLS WILL BE LOCATED PENDING REVIEW OF SOIL BORING/PIEZOMETER ANALYTICAL RESULTS.

FIGURE 3-3

ASH PIT NO.1 - PHASE 1
PROPOSED SOIL BORING AND TEMPORARY PIEZOMETER LOCATIONS

PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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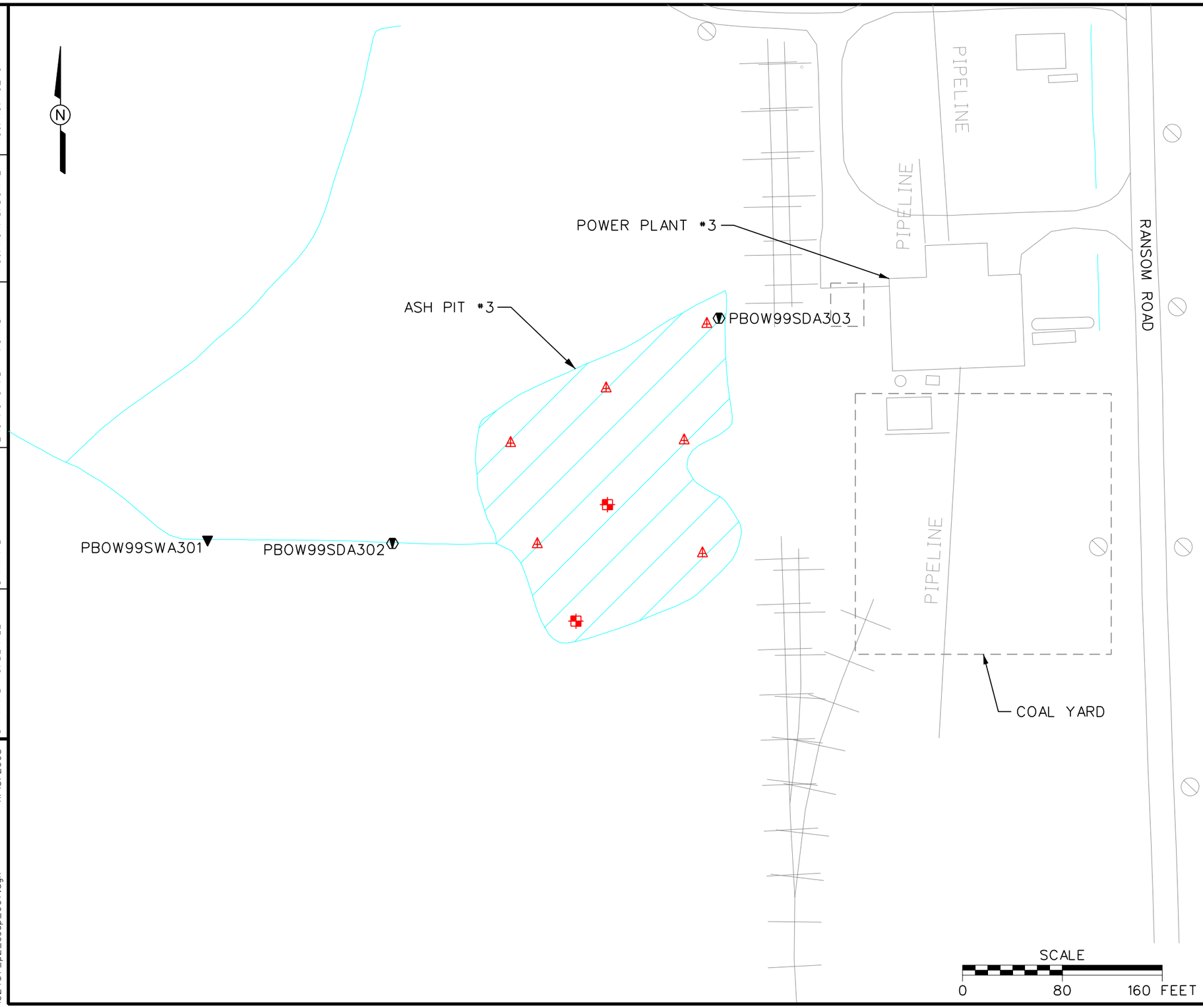

LEGEND:

- PREVIOUS SEDIMENT/SURFACE WATER SAMPLE (USACE, 2000)
- PREVIOUS SURFACE WATER SAMPLE
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER

NOTES:

1. PROPOSED LOCATIONS MAY BE MOVED BASED ON FIELD OBSERVATIONS.
2. PREVIOUS SEDIMENT SAMPLES COLLECTED IN 1999 (USACE, 2000, LIMITED SITE INVESTIGATION, FINAL REPORT, FOR THE FORMER PLUM BROOK ORDNANCE WORKS ASH PITS NO. 1 AND 3, SANDUSKY, OHIO, JULY).
3. THREE OVERBURDEN/SHALE AND THREE LIMESTONE BEDROCK MONITORING WELLS WILL BE LOCATED PENDING REVIEW OF SOIL BORING/PIEZOMETER ANALYTICAL RESULTS.

FIGURE 3-4

ASH PIT NO. 3 - PHASE 1
PROPOSED SOIL BORING AND TEMPORARY PIEZOMETER LOCATIONS

PHASE 2 WWTP1&3 AND AP1&3 SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 11/10/08	DATE LAST REV.:	DRAFT. CHCK. BY: C. BENTLEY	INITIATOR: D. KESSLER	132457_p2_ssap_007.dgn
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RESPONSE TO COMMENTS

Response to USACE Comments
Draft Site-Specific Sampling and Analysis Plan
Phase 2 Remedial Investigation
Waste Water Treatment Plants 1 & 3
And Ash Pits 1 & 3
Former Plum Brook Ordnance Works, Sandusky, Ohio
November 13, 2008

Review comments from Jim Beaujon, Geologist, Nashville District, received January 14, 2009.

Comment 1: **Page 1-1, middle of 2nd paragraph: Change "Phase I" to "Phase 1".**

Response 1: Revision will be made as suggested.

Comment 2: **Page 2-2, Section 2.3.3, final line on page: Change "groundwater well is" to "groundwater is".**

Response 2: Revision will be made as suggested.

Comment 3: **Page 3-4, 2nd paragraph, 8th line: Change "filter pack, followed" to something along the lines of "filter pack, allowed to hydrate with clean water for ____ hours, followed". Replace the "___" with the number, or fraction of, hours you propose to allow the bentonite seal to hydrate before topping with neat cement.**

Response 3: Agreed. The text will be revised to "An approximate*ly* 2- to 5-foot bentonite seal will be tremied to depth above the filter pack *and allowed to hydrate for at least one hour*. A neat cement/bentonite mixture (95 percent Type II or V portland cement and 5 percent bentonite powder mixed with 5 to 7 gallons clean water) *will be placed from the bentonite seal* to approximately 3 feet below grade.

Comment 4: **Page 3-4, 3rd paragraph: Edit the first line for clarity. Also, for the bedrock well borings mention what you will use to drill through the overburden and how you will set the casing.**

Response 4: Agreed. This paragraph will be replaced with the following text: "*The limestone bedrock monitoring wells will be 2-inch diameter and double cased. A pilot borehole for each well will be drilled until auger refusal using 4 l/4-inch hollow stem augers followed by overdrilling the borehole using 8 l/4-inch hollow stem augers. Five feet of competent bedrock will be drilled within the augers using an 8-inch outside diameter roller cone bit to allow for the installation of low carbon steel isolation casing. The steel isolation casing will be pressure grouted in place, and the grout allowed will be allowed to cure for at least 48 hours. Limestone bedrock borings will completed using a rock core bit, cutting a maximum 6-inch outside diameter (OD) borehole and a rock core tube 5 feet in length. If a*

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

Comment 5: **Page 3-5, 1st line: Change "photograph for distance" to "photograph for length".**

Response 5: Revision will be made as suggested.

Comment 6: **Page 3-7, Section 3.2.4, end of final paragraph (re surface component conditions): Revise according to revisions made to earlier SSAPs.**

Response 6: The referenced text will be revised consistent with the following: "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 …"

Comment 7: **Page 3-10, final bullet: Edit "degrees °C".**

Response 7: Text will be revised to eliminate "degrees".

Comment 8: **Page 3-12, 6th bullet: Change "should" to "shall".**

Response 8: To make consistent with other bulleted items above, "should" will be changed to "will."