Attachment XIII

Site-Specific Sampling and Analysis Plan
Continued Groundwater Remedial Investigation
Background and Off-Site Downgradient Groundwater

Former Plum Brook Ordnance Works, Sandusky, Ohio

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(This SSAP must be used in conjunction with the IT SAP, 1996a)

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List of Acronyms

ASTM	American Society for Testing and Materials
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BTEX	benzene, toluene, ethylbenzene and xylenes
°C	degrees Celsius
CLP	Contract Laboratory Program
COC	chemicals of concern
D&M	Dames and Moore
DERP	Defense Environmental Restoration Program
DNB	dinitrobenzene
DNT	dinitrotoluene
DOD	U.S. Department of Defense
DQO	data quality objective
Eh	oxygen reduction potential
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FS	feasibility study
ft	feet
FUDS	Formerly Used Defense Site
GWI	groundwater investigation
HTRW	hazardous, toxic, and radioactive waste
HQ	hazard quotient
ICI	International Consultants Incorporated
ID	identification
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IT	IT Corporation
LEL	lower explosive limit
MCL	maximum contaminant level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MK	Morrison-Knudson Corporation
ml/min	milliliters per minute
NASA	National Aeronautics and Space Administration

NTU	nephelometric turbidity unit
OD	outside diameter
OEPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbons
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyls
PID	photoionization detector
PPE	personal protective equipment
PRRWP	Pentolite Road Red Water Pond
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAO	remedial action objective
RBSC	risk-based screening concentration
RDX	Research and Department Explosive (cyclotrimethylenetrinitramine)
RGO	remedial goal objectives
RI	remedial investigation
SAIC	Science Applications International Corporation
SB	soil boring
SAP	sampling and analysis plan
Shaw	Shaw Environmental, Inc.
SHP	safety and health plan
SLERA	screening level ecological risk assessment
SO	other soils
SS	soil screening sample/or surface soil
SSAP	site-specific sampling and analysis plan
STL	Severn Trent Laboratory
SU	standard units
SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
TNB	trinitrobenzene
TNT	trinitrotoluene
TNTA	TNT Area A

List of Acronyms *(Continued)*

TNTB	TNT Area B
TNTC	TNT Area C
TOC	total organic carbon
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
VOC	volatile organic compound
WARWP	West Area Red Water Pond

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 properties. The former Plum Brook Ordnance Works (PBOW), is located in Sandusky, Erie County, Ohio (Figure 1-1). The PBOW is being investigated under the Defense Environmental Restoration Program (DERP) for Formerly Used Defense Sites (FUDS). 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.

As an attachment to the PBOW site-wide sampling and analysis plan (SAP) (IT Corporation [IT], 1996a), this site-specific sampling and analysis plan (SSAP) has been prepared by Shaw Environmental, Inc. (Shaw [formerly IT Corporation]) for the field work to be carried out in support of the continued groundwater remedial investigations (RI) at two red water pond areas, West Area Red Water Ponds (WARWP) and Pentolite Road Red Water Ponds (PRRWP), and three former trinitrotoluene (TNT) manufacturing areas, Area A (TNTA), Area B (TNTB), and Area C (TNTC). This work is intended to expand the investigation beyond NASA's Plum Brook Station boundaries both upgradient and downgradient. This SSAP must be used in conjunction with the SAP and the quality assurance project plan (QAPP) (IT, 1996c) 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-specific safety and health plan has also been prepared separately for this investigation and must be used in conjunction with the site-wide safety and health plan (IT, 1996b).

1.1 Site History

The PBOW site was built in early 1941 and manufactured 2,4,6-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 transferred to the Ordnance Department and then to the War Assets Administration after it was certified by the U.S. Army to be decontaminated. In 1949, PBOW was transferred to the General Services Administration. NASA acquired PBOW in 1963 and is presently utilizing the site.

1.2 Summary of Existing Site Data

Numerous investigations have been conducted at PBOW. The discussion of existing site data will focus on the primary areas to be investigated under this RI, which include the three TNT manufacturing areas (Areas A, B, and C), the Red Water Ponds Areas, and the Background Area. Although groundwater data are not subjected to risk assessment screening in this document, risk-based screening concentrations (RBSC) are included as points of reference. The groundwater RBSCs are derived from U.S. Environmental Protection Agency (EPA) (2002) 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 TNT Areas

TNT was manufactured in three areas, designated TNTA, TNTB, and TNTC (Figure 1-2). Each area had production lines consisting of a Mono House, a Bi-Tri house, a Fortifier House, and a Wash House used in the manufacture of TNT. In addition, other buildings (Nailing Houses, Wastewater Settling Tanks, DNT Sweating and Graining Houses, etc.) were present at each site. Each TNT area is discussed in the following paragraphs.

1.2.1.1 TNT Area A

The former TNTA is located in the northeastern part of PBOW and occupies approximately 114 acres of land. Columbus Avenue bisects the site, as shown in Figures 1-2 and 1-3. NASA constructed its administration building on the east side of Columbus Avenue in the central portion of former TNTA. The NASA Administration Building and associated parking areas cover two of the former TNT process buildings (Buildings 121 and 122) at TNTA. TNTA was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTA had four TNT lines, consisting of five buildings each, and two DNT lines, each consisting of one building (Figure 1-3). Wastewater from TNTA was routed to the PRRWP through underground flumes and sewer lines. Aboveground evidence of the former TNTA structures and features include abandoned railroad tracks, portions of foundations, soil mounds (indicative of former building foundations), roadways, ditches, manholes, drains, and water valves.

Significant previous remediation activities have been performed in TNTA. According to the records review report (Dames and Moore [D&M], 1995), TNTA was decontaminated, along with two other TNT areas in 1955 and again in 1966. The decontamination at TNTA was reportedly very thorough. Significant subsurface contamination was removed, including underground flumes and sewer lines. Approximately 16,000 pounds of TNT were removed from TNTA.

Previous environmental investigations in this area included a 1993 site inspection by Morrison-Knudsen Corporation (Morrison-Knudsen [MK], 1994) and a 1994 TNT areas site investigation by Dames and Moore (D&M, 1997a). The MK inspection of the TNTA site included one soil sample, one co-located sample each of surface water and sediments, and three groundwater samples. No explosives residues were detected in any of these samples.

A total of 36 soil samples were collected from 28 borings in the TNTA site during the 1994 D&M investigation. Boring locations were placed in and around former buildings that were associated with the TNT production lines. In addition, one soil boring was installed in a ditch north of Maintenance Road. A wide range of nitroaromatic compounds were detected, including concentrations of TNT up to 580 milligrams per kilogram (mg/kg) near the Wastewater Settling Tanks and 53 mg/kg near the Fortifier House. One boring (TNTA-S22-0.0/2.0) near Mono House exhibited 2,4-DNT and 2,6-DNT concentrations of 45 mg/kg and 47 mg/kg, respectively.

D&M also collected groundwater samples. There were seven existing monitoring wells in TNTA. Five are overburden wells (MK-MW22, -MW23, -MW24, and TNTA-MW10, and -MW11) and two are bedrock wells (BED-MW17 and -MW18). Ten nitroaromatics were detected, nine above RBSCs in the overburden wells. Five nitroaromatics were detected above RBSCs in the bedrock wells.

IT conducted a site-wide groundwater investigation at PBOW in 1996 (IT, 1997a) and again in November 1997 (IT, 1998). Both investigations included the collection of groundwater samples from wells in TNTA.

Eight nitroaromatics above RBSCs were detected in groundwater in overburden well MK-MW-22 in 1996 and 3 in 1997. Only 1 other nitroaromatic (2,6-DNT) above RBSCs in the overburden wells was detected during both years and it was from well MK-MW23 in 1996. Nitrobenzene was detected above the RBSC in 1996 in bedrock well BED-MW17 while 4-A2,6-DNT, was detected above the RBSC in well BED-MW18. The only nitroaromatics detected above RBSCs in 1997 were 1,3-dinitrobenzene (DNB) and nitrobenzene from well BED-MW18. Filtered inorganics from overburden wells above RBSCs in 1996 included arsenic (MK-MW23), manganese (MK-MW23, TNTA-MW10, and TNTA-MW11), vanadium (MK-MW24), and iron (MK-MW10). Filtered inorganics above RBSCs in 1997 included arsenic (MK-MW23), manganese (MK-MW22, MK-MW23, MK-MW24, TNTA-MW10, and TNTA-MW11), chromium, iron, vanadium (MK-MW24), barium, and iron (TNTA-MW10). Filtered inorganics

from bedrock wells above RBSCs in 1996 included only arsenic (BED-MW17) while in 1997, barium was detected above RBSCs in both wells.

Benzene, toluene, total xylenes, and methyl chloride were common semivolatile organic compounds (SVOC) detected above RBSCs in both bedrock wells during both years. Total cyanide was also detected above the RBSC in bedrock well BED-MW17 in 1997.

In May 1998, IT again conducted a site-wide sampling event. Nitroaromatic compounds (4-amino 2,6-DNT [4-A2,6-DNT] 2,4-DNT and 2,6-DNT) were detected above RBSCs in overburden well MK-MW22. Overburden well MK-MW23 showed bis(2-ethylhexyl)phthalate above RBSC values. Eleven metals were found to be above RBSC screening values in overburden wells in the unfiltered samples. Three metals were above RBSCs with manganese common to each overburden well. Two nitroaromatics (2,4-DNT and 2,6-DNT) were detected in bedrock wells above RBSCs, both concentrations from well BED-18. Of the bedrock wells, naphthalene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, methylene chloride, and total xylenes were detected above screening values in well BED-MW17, and benzene, total xylenes, naphthalene, and bis(2-ethylhexyl)phthalate were above limits in well BED-MW18. In well BED-MW17, arsenic (filtered) and barium (filtered and unfiltered) were the only metals detected above screening values.

The last week of June through October 2000, IT conducted a RI of TNTA to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, sediment and shallow groundwater. Four hundred twenty-seven soil samples were collected for field screening analysis of nitroaromatics, 39 confirmation soil samples, 10 (9 on-site, 1 off-site) surface water, 15 (10 on-site, 5 off-site) sediment samples and 10 shallow groundwater samples. It was determined that most of the nitroaromatic-impacted soil was encountered within 1 to 5 feet of the former building foundations. The largest nitroaromatic concentration of 2,4,6-TNT was located at Wash House, Building 146 (530 mg/kg), in a sample collected at 4 to 6 feet below ground surface (bgs).

Nine on-site surface water samples were collected, 8 from drainage areas and 1 from a suspect "red water" puddle at Wash House, Building 146. Three nitroaromatic compounds were detected in 2 samples from the drainage ditches with the highest concentration being 2.34 micrograms per liter (µg/L) of 4-A2,6-DNT. Three volatile organic compounds (VOC) compounds (acetone [2.95 µg/L], carbon disulfide [11.5 µg/L], and methylene chloride [3.75 µg/L]) and 1 semivolatile organic compoud (SVOC) (di-n-butyl phthalate [1.3 µg/L]) were detected. Twenty metals were also detected. The surface water sample from Wash House,

Building 146, was analyzed only for nitroaromatics. The TNT concentration from the surface water sample was 11,000 µg/L.

As part of the June through October 2000 RI, IT collected 9 shallow groundwater samples from confirmation soil sample locations which displayed the highest detections for PBOW related contaminants. Groundwater samples were collected from temporary piezometers and analyzed for VOCs, SVOCs, nitroaromatics, and metals. Three of the 9 groundwater samples (GW-02, GW-06, and GW-10) for metals were filtered.

Nitroaromatics were detected in all groundwater samples above RBSCs. TNT analytical concentrations ranged from nondetect (GW-01, GW-03, and GW-08) to 32,400 µg/L (GW-06). Total DNT was detected in 6 of the 9 samples with the highest analytical result of 13,800 µg/L in groundwater from GW-10. 4-A2,6-DNT and 2-A4,6-DNT were detected above RBSCs in 5 of the sampling locations. Benzene and toluene were the only VOCs above RBSCs in groundwater from temporary piezometer GW-01. Nitroaromatics 2,4-DNT and 2,6-DNT (detected as SVOCs) were the only SVOCs above the RBSC. 2,4-DNT was found at all temporary piezometers except GW-04 and GW-07 at concentrations as great as 5,750 µg/L (GW-10). 2,6-DNT was found in the groundwater at GW-01, GW-03, GW-08, and GW-10 at concentrations as great as 5,610 µg/L GW-10. Polychlorinated biphenyls (PCB) Aroclor 1260 was detected above its RBSC in the groundwater at GW-03. Fourteen unfiltered metals above RBSCs were detected at the temporary piezometers. Filtered manganese was the only inorganic detected above its RBSC. Unfiltered manganese was found above the RBSC at all of the sampling points. Unfiltered iron was above the RBSC in all piezometers except GW-10 while unfiltered aluminum, arsenic, chromium, and lead was found at all except GW-07 and GW-10.

A baseline ecological risk assessment (BERA) was performed by IT for TNTA (IT, 2001a). The BERA estimated that ecological hazards associated with TNTA surface and total soils were elevated. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTA soils be remediated to human health-based remedial goal options (RGO), and that ecological risk be re-evaluated in the focused feasibility study (FFS) based on cleanup of areas previously exceeding these RGOs. Because of uncertainties of estimating chemical concentrations in aquatic insects, the limited amount and low quantity of aquatic habitat, and the low hazard estimates, neither remedial action nor further study was recommended for surface water and sediment.

A baseline human health risk assessment (BHHRA) was also performed for TNTA for possible human exposure to soil, surface water, and sediment (IT, 2001b). Results of the BHHRA indicate that cumulative human health risks associated with TNTA total soil for the potential future resident and construction worker exceed the respective risk management ranges for cancer risk (i.e., incremental lifetime cancer risk [ILCR]>1E-5) and noncancer hazard (i.e., hazard quotient [HQ]>1). Exposure to surface water and sediment were found to contribute insignificantly to human health risks. Exposure to surface soil (as evaluated for the groundskeeper, indoor worker, and hunter/venison eater) resulted in noncancer and cancer risk estimates within or less than the risk management ranges. The chemicals of concern (COC) for TNTA total soil are lead, Aroclor 1260, and several nitroaromatics.

In 2002, IT prepared a draft FFS for soil at TNTA. The study is currently in review with in-situ chemical oxidation, excavation, ex-situ stabilization, and windrow composting as the recommended remedial alternatives for soil (IT, 2003a).

1.2.1.2 TNT Area B

TNTB comprises an area of approximately 55 acres in the south-central portion of PBOW, immediately north of West Scheid Road, as shown on Figures 1-2 and 1-4. Figure 1-4 presents a site map showing the locations of all former buildings. TNTB was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTB had three TNT lines consisting of 5 buildings each, and one DNT line consisting of one building. All of the buildings that were present during the TNT manufacturing period have been demolished but most foundations have been located during environmental investigations. Aboveground evidence of former PBOW facilities exist at TNTB in the form of roads, hydrants, and ditches. In addition, aboveground water valves indicate the presence of underground utilities.

Two NASA facilities present at the site are currently active, the Hypersonic Testing Facility and the Nitrogen Dewar Tanks. The Hypersonic Testing Facility is located on the site of the former Wash House, Building 476, in the northwest portion of TNTB. The facility consists of a single building, aboveground and underground piping and utilities, and paved parking areas. The Nitrogen Dewar Tanks are located in the center of TNTB, with aboveground piping and underground utilities leading to the northwest and to the northeast off site (D&M, 1997a).

As noted in Section 1.2.1.1, historical groundwater analytical results are compared to RBSCs. Soil analytical results are compared to site-specific RGOs developed by the feasibility study (FS) (IT, 2001c).

In 1993, MK collected 2 surface water, 2 sediment, and 2 surface soil samples in the vicinity of TNTB. The samples were analyzed for VOCs, SVOCs, nitroaromatics, and dissolved metals. Surface water sample SW07 and sediment sample SD07 were collected near the beginning of Ransom Brook, approximately 250 feet north of Magazine Road near the former Red Water Settling Tanks. Surface water sample SW08 and sediment sample SD08 were collected north of TNTB, approximately 200 feet south of Fox Road and approximately 3,000 feet downgradient of SW07 and SD07 (International Consultants Incorporated [ICI], 1995).

The surface water samples exhibited no detections of VOCs or SVOCs. No metals were detected in the surface water at concentrations above their maximum contaminant level (MCL) or secondary MCL. The sediment sample collected at SD07 had detections of five VOCs and fourteen SVOCs. Using the 10X rule (10 times the soil RGO to account for less exposure), all were below RGO screening levels. The only nitroaromatic detection in SD07 was TNT at a concentration of 25 mg/kg, below the 10X rule of the soil site-specific cleanup level of 3.36 mg/kg (IT, 2001c). Eleven organic compounds were detected in sediment sample SD08, all at concentrations of 0.1 mg/kg. Detected organic compounds included two VOCs and nine SVOCs, eight of which were polynuclear aromatic hydrocarbons (PAH). All were less than the site-specific RGO.

The two surface soil sample locations were designated SB09 and SS13. SB09 was collected from the borehole for monitoring well MK-MW17. Sample SS13 was collected in the vicinity of the railroad tracks southwest of the Fortifier House, Building 463 (ICI, 1995). VOCs (toluene and xylenes), SVOC (bis[2-ethylhexyl]phthalate), and nitroaromatics (TNT and 2,6-DNT) were detected in the surface soil. Nitroaromatics were present at SB09, with TNT detected at a concentration of 12 mg/kg.

Two overburden monitoring wells were installed at TNTB in July 1993 by MK. Well MK-MW16 is located upgradient and well MK-MW17 is located downgradient of TNTB. Groundwater samples collected from both wells were analyzed for VOCs, SVOCs, nitroaromatics, and dissolved metals. No VOCs or nitroaromatics were detected in either of the wells. Twelve unfiltered metals were detected at levels that exceeded RBSCs. One SVOC, bis(2-ethylhexyl)phthalate, was detected at a concentration of 12 μg/L in MK-MW17.

In October 1994, as part of the TNT areas site investigation, D&M sampled soil at 26 locations at TNTB. All samples were collected between 0.5 and 3.5 feet bgs. Eighteen of the 26 locations were sampled at one depth, and 8 locations were sampled at two depths. The samples were analyzed for nitroaromatics and metals. Nitroaromatics were detected in 18 of the 26 locations,

and most locations had at least one sample with a concentration greater than 1.0 mg/kg. Concentrations of nitroaromatics detected in excess of 10,000 mg/kg were present in soils at the Bi-Tri House for Line 5 (Building 452) and the DNT Sweating and Graining House (Building 412).

In December 1994, D&M sampled both MK-MW16 and MK-MW17 as part of the TNT areas site investigation. Samples from the wells were analyzed for nitroaromatics, nitrates, and unfiltered and filtered concentrations of 14 metals, the 13-priority pollutant metals plus manganese. MK-MW16 did not exhibit any detection of nitroaromatics. The downgradient well MK-MW17 contained 6 nitroaromatics (4-A2,6-DNT, 2-A4,6-DNT, 2,4-DNT, 2,6-DNT, 3,4-DNT, and 2,4,6-TNT) that exceed RBSCs. Nitrates were detected, but at concentrations below RBSCs. Five metals were detected above RSBCs in unfiltered overburden groundwater: arsenic, cadmium, manganese, nickel, and thallium. Three of the metals (manganese, nickel, and thallium) were detected in both wells. Four metals (antimony, manganese, nickel, and thallium) were detected above RBSCs in filtered groundwater samples. Manganese and nickel were common to both wells.

In September and October 1996, IT collected groundwater samples from MK-MW16 and MK-MW17 as part of the site-wide groundwater investigation. Both groundwater samples were analyzed for VOCs, SVOCs, metals, pesticides, PCBs, cyanide, and nitroaromatics. SVOCs, pesticides, and cyanide were not detected, and VOCs were not detected above RBSC levels. Seven metals were detected above screening levels; aluminum, arsenic, cobalt, iron, lead, manganese, and nickel. Seven nitroaromatics were detected above levels in MK-MW17. The maximum concentration of any nitroaromatic detected in MK-MW17 was 11 µg/L of 2,6-DNT.

In 1997, IT installed two bedrock wells near TNTB. TNTB-BEDGW-001 was installed northwest of the site to monitor bedrock groundwater downgradient of TNTB, and TNTB-BEDGW-002 was installed south of TNTB to monitor bedrock groundwater upgradient of the site.

In November 1997 and May 1998, as part of the semiannual monitoring portion of the groundwater investigation, overburden wells MK-MW16 and MK-MW17 were sampled by IT. Overburden groundwater samples were analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters (alkalinity, chloride, hardness, sulfate, nitrate, total dissolved solids, total organic carbon, and total suspended solids) (IT, 1999).

During 1997, no VOCs, SVOCs, cyanide, or water quality parameters exceeded RBSCs. Overburden groundwater samples analyzed for dissolved metals exceeded screening levels for arsenic, cobalt, iron, manganese, and nickel in MK-MW17 and aluminum, iron, and manganese in upgradient well MK-MW16. Only one nitroaromatic compound, 4-A2,6-DNT, was detected above its RBSC. This exceedance occurred only in downgradient well MK-MW17. No SVOCs, cyanide, or water quality parameters exceeded screening levels in bedrock wells TNTB-BEDGW-001 and -002. Two VOCs, benzene and methylene chloride, were detected at concentrations above their RBSCs in well TNTB-BEDGW-002. No nitroaromatics were detected in either well. Filtered and unfiltered bedrock groundwater samples in TNTB-BEDGW-001, analyzed for metals, exhibited RBSC exceedances for iron and manganese. Bedrock well TNTB-BEDGW-002 exhibited RBSC exceedances for barium in the filtered and unfiltered phases.

In May 1998, IT again sampled groundwater from site-wide monitoring wells. Overburden well MK-MW17 exhibited nitroaromatic compounds 4-A2,6-DNT and 2-4 DNT above the RBSC. No VOCs were above screening levels. Nitroaromatic 2,4-DNT (detected as a SVOC) was above its RBSC. Metals above screening levels in the overburden wells were limited to iron, manganese, and nickel in MK-MW16 and aluminum, arsenic, iron, manganese, and nickel in MK-MW17, all in the filtered and unfiltered groundwater samples. Bis(2-ethylhexyl)phthalate was the only SVOC found above its screening level in the bedrock well TNTB-BEDGW-001. Detected metals above RBSCs in the bedrock wells were arsenic, barium, iron, and manganese in TNTB-BEDGW-001 in the unfiltered phase and barium and manganese in the filtered phase. Bedrock well TNTB-BEDGW-002 exhibited only barium (filtered and unfiltered) above its RBSC.

In October and November 1998, IT conducted a RI of TNTB to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, and sediment. Three hundred ninety-one soil samples were collected for field-screening analysis of nitroaromatics, and 40 confirmation samples, two surface water, and five sediment samples were collected. It was determined that most of the nitroaromatic-impacted soil above site-specific RGOs was encountered within 1 to 5 feet of the former building foundations. A total of 23 soil samples with nitroaromatic compounds above site-specific RGOs were recorded, with the highest detected 2,4,6-TNT concentration (6,900 mg/kg) being located at the Bi-Tri House, Building 452, in a 0 to 1 foot bgs sample. Wash House, Building 456, exhibited 6 soil sample concentrations of 2,4,6-TNT, 4-A2,6-DNT and 2-A4,6-DNT nitroaromatics above RGOs. Surface water results indicated that only VOCs and metals were present, while sediment analytical results showed VOCs, SVOCs, and metals (IT, 2000a).

A BHHRA and screening level ecological risk assessment (SLERA) were performed for TNTB (IT, 2000b). Total soil was found to exceed the cancer (1E-5) and noncancer cumulative risk management ranges for both receptors evaluated (potential future resident and construction worker). Likewise, surface soil was found to exceed the respective risk management ranges for both receptors evaluated (groundskeeper and indoor worker). Thirteen human health risk COCs were identified in TNTB surface and total soils. Site-related human health risks associated with surface water and sediment were found to be within or less than the risk management ranges (i.e., ILCR$\leq$1E-5 and HI$\leq$1).

The SLERA estimated that ecological hazards associated with TNTB surface and total soils were elevated. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTB soils be remediated to human health-based cleanup levels. The resulting residual ecological risks to terrestrial receptors were re-evaluated in the FFS based on cleanup of areas previously exceeding the cleanup levels. The resulting ecological risks were estimated to be reduced an average of approximately 750-fold. The SLERA concluded that remediating the site to human health cleanup levels would result in residual concentrations that are protective of terrestrial receptors. Additionally, the SLERA found that due to the limited aquatic habitat and the lack of rare, threatened, or endangered species, that the development of remedial action objectives (RAO) based on aquatic receptors was unwarranted.

IT generated a FS for TNTB in July 2001. Site-specific cleanup levels for TNTB surface and subsurface soil for each of the COCs are as follows (IT, 2001c):

Chemical of Concern	TNTB Cleanup Level (mg/kg)
Nitroaromatics	
2-amino-4,6-DNT	0.40
4-amino-2,6-DNT	0.40
2,4-DNT	7.50
2,6-DNT	2.75
2-Nitrotoluene	74
2,4,6-TNT	3.36
Polychlorinated Biphenyls	

Chemical of Concern	TNTB Cleanup Level (mg/kg)
Aroclor 1254	0.16
Aroclor 1260	2.87
Polynuclear Aromatic Hydrocarbons	
Benzo(a)anthracene	5.43
Benzo(a)pyrene	0.54
Benzo(b)fluoranthene	5.43
Dibenz(a,h)anthracene	0.65
Indeno(1,2,3-cd)pyrene	5.43

In September 2002, the USACE initiated the removal action of contaminated soil at TNTB. Soil above the site-specific clean-up level will be excavated, stabilized, and transported off-site for disposal.

1.2.1.3 TNT Area C

The former TNTC, located in the southwestern portion of PBOW, occupies approximately 119 acres of land, as shown in Figures 1-2 and 1-5. NASA currently uses some of the remaining structures in the area for storage purposes. TNTC was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTC contained five TNT lines consisting of five buildings each (Figure 1-5). Wastewater from TNTC was routed to the PRRWP through underground flumes and sewer lines.

Presently, the area is largely overgrown with trees and brush; however, some of the roads, building foundations, manholes, drains, and remnants of utilities from former TNT operations are still recognizable. According to the records review report (D&M, 1995), TNTC was decontaminated, along with two other TNT areas in 1955 and again in 1966. However, the decontamination at TNTC was reportedly not as thorough as that in TNTA, and significant subsurface contamination associated with underground flumes and sewer lines is probably still present.

Previous environmental investigations in this area included a 1993 site inspection by MK (1994) and a 1994 TNT areas site investigation by D&M (1997a), groundwater investigations by IT in 1996, 1997, and 1998, and a soil, surface water/sediment investigation by Shaw in 2000. As noted in Section 1.2.1.1, historical groundwater analytical results are compared to RBSCs.

The MK inspection of the TNTC site included two surface soil samples and one collocated pair of surface water and sediment samples. Organic compounds were not detected in the surface water sample nor in the collocated sediment sample. Toluene was detected in both surface soil samples at concentrations below the quantitation limit.

A total of 30 soil samples were collected from 26 borings within the TNTC site during the 1994 D&M investigation. Boring locations were placed in and around former buildings that were associated with the TNT production lines (Line 12 - Buildings 626, 612, and 604). A wide range of nitroaromatic compounds were detected, including TNT at concentrations up to 2.7 mg/kg (near Building 626) and 2,4-DNT up to 8.7 mg/kg (near Building 626).

D&M also collected groundwater samples from wells in TNTC. There were 4 overburden wells present (TNTC-MW03, TNTC-MW04, TNTC-MW05, and TNTC-MW06) and one bedrock well (BED-MW13). Overburden wells TNTC-MW03 and TNTC-MW04 were not sampled due to insufficient water present during sampling activities (D&M, 1997a). One nitroaromatic (2,4-DNT) was detected slightly (0.1 µg/L) above its RBSC in overburden well TNTC-MW05. No VOCs, SVOCs, nitrates, or water quality parameters were detected above RBSCs. Inorganics above RBSCs included aluminum (filtered) and manganese (filtered and unfiltered) in well TNTC-MW05 and chromium (filtered and unfiltered), iron (unfiltered), and manganese (filtered and unfiltered).

Four nitroaromatic compounds (4-A2,6-DNT, 2,4-DNT, 2,6-DNT, and 3-nitrotoluene) were detected above RBSCs in the bedrock well BED-MW13. VOCs and SVOCs above RBSCs included benzene, toluene, total xylenes, 2-methylnaphthalene, and naphthalene. Antimony (filtered) was the only inorganic detected above its RBSC.

IT conducted a site-wide groundwater investigation at PBOW in 1996 (IT, 1997a) and again in 1997 (IT, 1998). The investigations included collection of groundwater samples from four overburden monitoring wells (TNTC-MW03, TNTC-MW04, TNTC-MW05, and TNTC-MW06) in 1996 and five wells (the previously sampled four wells and IT-MW09) in 1997. One bedrock monitoring well, BED-MW13 was also sampled during both events.

No VOCs above RBSCs were detected in the overburden groundwater in 1996 or 1997. The SVOC bis(2-ethylhexyl)phthalate was detected above its RBSC in TNTC-MW06 in 1997. Nitroaromatics were not detected during either sampling event. Filtered and unfiltered manganese was detected above its RBSC in all overburden wells during both sampling events. Unfiltered iron was detected above its RBSC in all overburden wells in 1996 and in wells TNTC-

MW04, TNTC-MW05, and TNTC-MW06 in 1997. Other filtered and unfiltered metals above RBSCs in 1996 included chromium, cobalt, lead, nickel, and vanadium in groundwater in TNTC-MW03, lead and vanadium in well TNTC-MW04, and chromium in well TNTC-MW06. Nitrate was detected above its RBSC in well TNTC-MW04 during the 1997 sampling event.

Several constituents were detected in bedrock well BED-MW13 in 1996 and 1997. Three nitroaromatics, 4-A-2,6-DNT, 2,6-DNT, and nitrobenzene were detected above their RBSCs in 1996. VOCs detected above their RBSCs were benzene, toluene, and total xylenes in 1996 and 1997. SVOCs, naphthalene, and 2-methylnaphthalene had detected concentrations exceeding their RBSCs in 1996 and 1997, bis(2-ethylhexyl)phthalate exceeded its RBSC limit. Barium was above the RBSC in both the filtered and unfiltered samples during the 1996 and 1997 sample events and chromium was above its RBSC in 1996 in only the filtered sample.

In May 1998 site-wide groundwater sampling, no nitroaromatics were detected in the overburden or bedrock monitoring wells. No VOCs or SVOCs were detected above RBSC levels in the overburden wells. Filtered and unfiltered manganese was detected above its RBSC in all overburden wells in 1998. Unfiltered metals aluminum, arsenic, chromium, and iron were detected above RBSC values in well TNTC-MW03; aluminum and iron in TNTC-MW04; aluminum, arsenic, chromium, iron, and lead in TNTC-MW05; and only iron in well TNTC-MW06. VOC contaminants benzene, methylene chloride, toluene, and total xylenes were above RBSCs in bedrock well BED-MW13. SVOCs above RBSCs included bis(2-ethylhexyl) phthalate, 2-methylnaphthalene, and naphthalene. No metals exceeded RBSC values in filtered or unfiltered samples in 1998.

During the last week of June through October 2000, IT conducted an RI of TNTC to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, sediment, and shallow groundwater. Three hundred eighty-three soil samples were collected for field-screening analysis of nitroaromatics, and 40 confirmation samples, 10 surface water samples, and 15 sediment samples were collected for a confirmatory analysis. During excavation for soil sample placement, most of the former building foundations were located. As at TNTB, it was determined that most of the nitroaromatic-impacted soil was encountered within 1 to 5 feet of the former building foundations. The highest detection was 54,969 mg/kg of 2,4,6-TNT in a sample collected from 0.25 to 1.25 feet bgs at the former Bi-Tri House (Building 692). It should be noted that this sample was of a suspected waste product from a clay line that was encountered during excavation at the former building. Surface water results indicated that only VOCs and metals were present, while sediment analytical results showed VOCs, SVOCs, and metals.

Based on the low concentrations of the contaminants in the soil, surface water, and sediment, concentrations were believed not to be attributable to former site activities (IT, 2001d).

As part of the June through October 2000 RI, IT collected 9 shallow groundwater samples from confirmation soil sample locations that displayed the highest detections of PBOW-related contaminants. Groundwater samples were collected from temporary piezometers and analyzed for VOCs, SVOCs, nitroaromatics, and metals. Three of the 9 groundwater samples (GW-04, GW-06, and GW-10) for metals were filtered.

Nitroaromatics were detected in all groundwater samples above the RBSCs. TNT analytical concentrations ranged from 0.208 µg/L (GW-07) to 20,100 µg/L (GW-08). Total DNT was detected in all but one sampling point (GW-03) with concentrations as great as 21,100 µg/L in GW-08. 4-A2,6-DNT was detected above its RBSC at all sampling piezometers. Benzene was the only VOC above its RBSC; it was found in temporary piezometers GW-03 and GW-09. Nitroaromatic 2,4-DNT (detected as an SVOC) was found above its RBSC at all sampling points except at GW-03 and GW-06. Detected as an SVOC, 2,6-DNT was also found above its RBSC at all the temporary piezometers except GW-03, GW-05, GW-06, and GW-07. Sixteen unfiltered metals above RBSCs were found in groundwater at the temporary piezometers. Unfiltered manganese was found to be above its RBSC at all of the sampling points. Unfiltered aluminum, arsenic, iron, and lead were above RBSCs at all temporary piezometers except GW-10.

A BERA was performed for TNTC (IT, 2001a), which estimated that ecological hazards associated with exposure to TNTC surface and total soils were elevated for terrestrial receptors. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTC soils be remediated to human health-based RGOs, and that ecological risk be re-evaluated in the FFS based on cleanup of areas previously exceeding the human health RGOs for TNTC. Also, neither remedial action nor further study are recommended for aquatic receptors exposed to TNTC surface water based on the following: uncertainties associated with estimating chemical concentrations in aquatic insects, limited area and low quality of aquatic habitat, and relatively low hazard estimates, especially when using the lowest-observable-adverse-effects-level approach.

A BHHRA was also performed for exposure to TNTC soil, surface water, and sediment (IT, 2001b). Results of the BHHRA indicate that cumulative human health risks associated with total soil for the potential future resident and construction worker exceed the respective risk

management ranges for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1). Similarly associated with exposure to surface soil for the groundskeeper, indoor worker, and adult hunter exceeded the respective risk management ranges. Noncancer risks associated with exposure to sediment for the potential future resident and construction worker also exceeded the risk management range (i.e., ILCR>1E-5), and cancer risks associated with exposure to sediment contributed significantly (ILCR>1E-6) to the overall ILCR of the construction worker and potential future resident. Human health risk-based RGOs for TNTC soil and sediment are being developed as cleanup criteria in the TNTA and TNTC FFS.

In 2002, IT prepared a draft FFS for soil at TNTC. The study is currently in review with in situ chemical oxidation, excavation, ex situ stabilization, and windrow composting as the recommended remedial alternatives for soil (IT, 2003a).

1.2.2 Red Water Pond Areas

1.2.2.1 West Area Red Water Pond

The WARWP is located on the western edge of PBOW, near the intersection of Campbell Street and Fox Road and to the north and west of Pipe Creek, as shown in Figures 1-2 and 1-5. Two former red water pond areas in the WARWP have been identified through the use of aerial photographs, site reconnaissance, and the presence of nitroaromatic compounds in soil and groundwater. As noted in Section 1.2.1.1, historical groundwater analytical results are compared to RBSCs.

Prior to 1985, numerous studies were conducted of the surface water and sediment from the Red Water Pond Areas. The Ohio National Guard conducted surface sediment screening for TNT and DNT. The highest values found in the screened sediments were less than 1 mg/kg (IT, 2000a). IT was contracted in 1989 to conduct near-surface sediment sampling to determine the presence or absence of residual chemical contamination from PBOW operations. Soil sample analysis showed that DNB, trinitrobenzene (TNB), DNT, and TNT were present in the soils at the WARWP. In 1991, Science Applications International Corporation (SAIC) confirmed that hazardous substances had been released into the environment at the WARWP (USACE, 1997).

A site inspection by MK from June through July 1993 to determine the potential risk to human health and the environment indicated low levels of VOCs and SVOCs in the sediments around Pipe Creek near the WARWP area but found no contaminant concentrations of VOCs, SVOCs, or nitroaromatics in the surface water. MK also installed four overburden groundwater monitoring wells (MK-MW09, MK-MW10, MK-MW11, MK-MW12) near WARWP and had

the groundwater analyzed for the above contaminants. Laboratory analysis did not indicate the presence of VOCs, SVOCs, or nitroaromatics in the groundwater samples near Pipe Creek (MK, 1994).

In 1994, D&M conducted a focused RI to evaluate groundwater occurrence and flow conditions in the overburden and bedrock water-bearing zones; assess groundwater quality in the overburden water-bearing zone; and investigate the baseline groundwater quality of the bedrock water-bearing zone to evaluate the necessity of additional work at PBOW. Two bedrock wells (BED-MW14 and BED-MW19) and two overburden wells (WA-MW01 and WA-MW02) were installed in the vicinity of the WARWP area. Hydrogeologic data indicated that groundwater flow in the overburden exhibited a strong downward vertical component and the presence of groundwater was strongly seasonally dependent. The general groundwater flow in both water-bearing zones was determined to be to the north toward Lake Erie. Groundwater samples were analyzed for VOCs, SVOCs, nitroaromatics, and metals. Significant concentrations of nitroaromatics were determined to be present adjacent to the ponds in both the overburden and the bedrock water-bearing zones. VOCs and SVOCs were also present in the bedrock wells. Some metals (antimony, manganese, and nickel) were also detected at concentrations exceeding their RBSCs (D&M, 1997a).

As part of the 1994 focused RI, to identify and evaluate the source, nature, and extent of contamination of former Department of Defense (DOD) activities, surface and subsurface soil at the Red Water Ponds was investigated by D&M. Soil samples were collected from the WARWP and analyzed for nitroaromatics and metals. Nitroaromatics 1,3,5-TNB and 2,4-DNT were most commonly detected (D&M, 1997a).

IT conducted groundwater investigations in 1996 and 1997. Both investigations indicated that the overburden had been impacted by nitroaromatic compounds in the central portion of the WARWP and that inorganic compounds were present at concentrations exceeding screening values throughout the area. IT determined that the bedrock water-bearing zone was impacted by nitroaromatics and other organic and inorganic compounds north of the WARWP, but not in the central portion of the area. IT recommended additional subsurface investigations to determine the nature and extent of contamination in these areas. Additional investigation should be conducted after background levels are established for metals in groundwater due to the possibility of inorganic screening levels being greater than calculated background values (IT, 1997a). Groundwater sampling of the WARWP groundwater wells in November 1997 and May 1998 indicated continued elevated levels of nitroaromatics (IT, 1999).

IT conducted a soil and groundwater risk assessment and direct-push investigation in June and November 1998 at the WARWP. A total of 19 surface soil, 37 subsurface soil, and 15 groundwater samples were collected. Four nitroaromatic compounds were detected in soil samples in direct-push borings DP09, DP10, DP11, and DP18. Groundwater samples collected from direct-push borings with detected nitroaromatics exceeding RBSC levels included DP08, DP09, DP11, DP12, DP13, DP15, and DP17. A maximum nitroaromatic concentration of 680 µg/L of 1,3,5-TNB, 270 µg/L of 1,3-DNB, and 950 µg/L of 2,4-DNT was detected in DP13, 7.1 µg/L of 2,4,6-TNT was detected in DP11 and 2.7 µg/L of 2,6-DNT was detected in DP09 (IT, 2000a).

A BERA was performed by IT in 2001 for the WARWP (IT, 2001d). Preliminary screening suggested that elevated PAH concentrations in soil and iron concentrations in sediment would pose an ecological concern. However, the areas of concern appeared to be very localized and a refined food-chain model demonstrated no adverse affects. Based on these findings, the ecological risk assessment concluded that remedial actions to address the ecological concerns for soil or sediment were not warranted.

A BHHRA was also performed for exposure to WARWP soil, surface water, and sediment (IT, 2000a). Results of the BHHRA indicate that site-related cumulative human health risks do not exceed the respective risk management levels for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1) when summed across all media for any of the receptors evaluated. An FFS was performed for the two Red Water Pond Areas (IT, 2002a). Because no WARWP COCs were identified in the BHHRA, the FFS did not identify or evaluate any remedial alternatives for the WARWP.

1.2.2.2 Pentolite Road Red Water Ponds

The PRRWP are located in the north-central portion of the PBOW facility, north of Maintenance Road, as shown in Figures 1-2 and 1-6, and south-southeast of the Reactor Building Area across Pentolite Road. As noted in Section 1.2.1.1, historical groundwater analytical results are compared to RBSCs.

In April 1977, Plum Brook Station personnel reported pockets of reddish brown water in the small surface ditch east of and adjacent to the PRRWP. The source of the reddish brown water was discovered to be a broken drain tile that was formerly used to drain the ponds. As a corrective action, retention dikes and sump pits were excavated to prevent further leakage of the material to the stream. Approximately 60,000 gallons of the "red" water were removed by a private contractor and grading and drainage improvements were made to the area. The action

also included backfilling of the former ponds and excavation of a new drainage ditch approximately 300 feet east of the ponds to reduce standing surface water (D&M, 1997a).

In 1984, Battelle Laboratories collected a surface soil sample from the spoils area at WARWP. Concentrations of nitroaromatics were detected in the low-parts per million range (IT, 2000a).

In 1989, IT conducted an evaluation to determine whether residual chemical contamination was present from former DOD activities at the Red Water Pond Areas. Soil samples from borings IT-SB13 through IT-SB18 were collected at the PRRWP area. Overburden monitoring well IT-MW05 was also installed on the northern edge of the PPRWP, in a suspected downgradient location. 2,4-DNT and 2,6-DNT were detected in soils at concentrations of at least 0.740 part per million and sodium concentrations in samples from six of the borings exhibited concentrations above the background levels (IT, 2000a).

In 1993, MK conducted a site inspection to assess the threat posed to human health and the environment and to determine the need for additional investigations. Surface soil and sediment samples were collected and analyzed from a drainage ditch along Pentolite Road, north of the PRRWP area. No samples from the Pentolite Road ditch showed detectable levels of VOCs, SVOCs, or nitroaromatics (MK, 1994).

As part of the 1994 Focused RI, to identify and evaluate the source, nature, and extent of contamination of former DOD activities, D&M investigated surface and subsurface soil at the Red Water Ponds. Soil samples were collected and analyzed for nitroaromatics and metals. Nitroaromatics 1,3,5-TNB and 2,4-DNT were most commonly detected (D&M, 1997a).

From May to June of 1994, D&M conducted a groundwater investigation (GWI) to evaluate groundwater conditions in several areas at PBOW. One scope of work included the assessment of groundwater quality in the overburden and bedrock water-bearing zones at the PRRWP area. Overburden monitoring wells PR-MW7, PR-MW8, and PR-MW9 and bedrock monitoring well BED-MW15 was installed. The investigation found that the groundwater flow in the overburden exhibited a strong downward vertical component and the presence of groundwater in the overburden was seasonally dependent. Groundwater sample results indicated that nitroaromatics were present in the overburden water-bearing zone, while lower levels of nitroaromatics were present in the bedrock water-bearing zone (D&M, 1997b).

A site-wide GWI performed by IT in 1996 determined that the overburden water-bearing zone had been impacted by nitroaromatic compounds and that the bedrock water-bearing zone had

been impacted by benzene, toluene, ethylbenzene, total xylene (BTEX), SVOCs, and nitroaromatics (IT, 1997a). Groundwater sampling events in November 1997 and May 1998 indicated continued elevated concentrations of nitroaromatic compounds (IT, 1999).

IT conducted a soil and groundwater risk assessment and direct-push investigation in June and November 1998 at the PPRWP. A total of 20 surface soil, 39 subsurface soil, and 20 groundwater samples were collected. Nitroaromatic compounds were detected in soil samples in direct-push borings DP01, DP02, DP03, DP06, DP09, DP10, DP11, and DP16. Maximum concentrations included 9.3 mg/kg of 1,3-DNB and 25 mg/kg of 2,4-DNT in DP03 (4 to 5 feet), 1.7 mg/kg of 2,6-DNT in DP10 (9 to 10 feet), and 2.7 mg/kg of 4A-2,6-DNT in boring DP11 (0 to 2 feet). Groundwater samples with detected nitroaromatics exceeding RBSCs included DP01, DP03, DP04, DP06, DP07, DP08, DP10, DP11, DP12, DP13, DP17 and DP18. A maximum nitroaromatic concentration of 600 µg/L of 1,3,5-TNB was detected in DP11, 4,800 µg/L of 1,3-DNB, 6,800 µg/L of 2,4-DNT in DP03, and 400 µg/L of 2,6-DNT was detected in DP10 (IT, 2000a).

A BERA was performed by IT for the PRRWP in 2001 (IT, 2001d). Results of the risk assessment showed that environmental media at the PRRWP do not appear to pose significant or unacceptable risks to ecological receptors.

A BHHRA was also performed for exposure to PRRWP surface soil and total soil (IT, 2000a). Results of the BHHRA indicate that cumulative human health risks associated with total soil exceed the respective risk management ranges for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1) in the potential future resident. Also, the noncancer hazards for the construction worker also exceed the risk management range for exposure to total soil. Six nitroaromatics and benzo(a)pyrene COCs were identified in the BHHRA.

An FFS was conducted for the two Red Water Pond Areas (IT, 2002a). The FFS evaluation of the PRRWP was initially based on the BHHRA and the COCs identified therein. During the FFS, a single location with elevated nitroaromatic concentrations, particularly TNT, was identified. It was determined that if this small "hot spot" was remediated, then the remaining soil would not pose a cancer risk nor noncancer hazard for any PRRWP receptor at levels exceeding the respective risk management ranges. In the Fall/Winter of 2002, the USACE initiated the removal action of contaminated soil at the PRRWP. Soil from the removal action was disposed in April 2003.

1.2.3 Background Wells

The background wells or the hydrogeologic upgradient area is located in the extreme west and southwest portion of the PBOW facility, along and west of the Patrol Road (Figure 1-7). As noted in Section 1.2.1.1, background groundwater analytical results are compared to RBSCs.

Previous environmental investigations include the 1994 D&M site investigation (D&M, 1997a) and a 1997 G-8 Burning Ground investigation by IT (IT, 1997b). As part of the 1994 investigation by D&M, background monitoring well BED-MW20 was installed and as part of the G-8 Burning Ground investigation, installation of upgradient bedrock well BG8-BEDGW-001 was conducted. Because both of these wells are positioned in upgradient locations of the PBOW site and no nitroaromatics had previously been detected in the groundwater, it was determined that they may also be used for collection of groundwater in the background groundwater assessment.

As part of a 2001 groundwater remedial investigation, IT installed 10 bedrock monitoring wells, 3 of which (BED-MW24, BED-MW25, and BED-MW26) were located in possible background positions (Figure 1-7). The intent of these wells along with BG8-BEDGW-001 and BED-MW20, is to use analytical results of the groundwater collected by low-flow sample collection methodologies for determination of the background distribution of inorganics, PAHs, and BTEX. Six background groundwater sampling events have been performed by IT. Based on historical precipitation records for the PBOW area, the sampling quarters were able to be designated as either a "wet" or "dry" sampling period. After well installation, all background wells were sampled quarterly as shown below:

- September/October 2001 (dry sampling period) (IT, 2001e)
- January 2002 (wet sampling period) (IT, 2002b)
- April 2002 (wet sampling period) (IT, 2002c)
- July 2003 (dry sampling period) (IT, 2003b)
- October 2002 (dry sampling period) (IT, 2003c)
- April 2003 (wet sampling period). November 1997 and May 1998 analytical results for wells BED-MW20 and BG8-BEDGW-001 were included for additional analytical information (Report distributed in July 2003).

At least one of three nitroaromatic compounds (2,6-DNT, nitrobenzene, and research and development explosive [RDX]) were detected in three (BED-MW20, BED-MW24, and BED-

MW25) of the five background wells during the background sampling events November 1997 to October 2002. Nitrobenzene was found in wells BED-MW20, BED-MW24, and BED-MW25 (April 2002) and in well BED-MW25 in October 2002. Nitroaromatics (2,6-DNT and RDX) were detected in groundwater from BED-MW24 only in April 2002. It should be noted that explosive compound RDX, as detected in well BED-MW24, was not manufactured at PBOW. Benzene was a common contaminant in groundwater in wells BED-MW20 and BED-MW24 and also was detected once (October 2001) in BED-MW25. Total xylenes and toluene were also regularly found in the groundwater in well BED-MW24. Naphthalene was the only SVOCs frequently detected and it was in BED-MW24 (October 2001 through July 2002). Fifteen different unfiltered metals were detected in the background wells. Barium, iron, and manganese were the metals most commonly detected in the unfiltered and filtered samples (IT, 2003c).

Based on water level measurements and the detection of 2,6-DNT, nitrobenzene, and RDX in the groundwater, it was interpreted that monitoring well BED-MW24 may not be a background monitoring well. A reinterpretation of the bedrock groundwater flow showed that well BED-MW24 may possibly be downgradient of the WARWP. It was determined that additional monitoring wells near well BED-MW24 may be needed to determine if the reinterpretation was correct and the monitoring well should be excluded from the background data set. Nitrobenzene was detected in wells BED-MW20 and BED-MW25. Groundwater analytical results from further upgradient monitoring wells will need to be reviewed to determine if nitrobenzene may be related to anthropogenic sources in addition to TNT manufacturing processes. Groundwater was encountered in bedrock monitoring well BED-MW26 but after installation, the water-producing fracture began to heal. After the initial column of groundwater in the well was removed, sufficient groundwater never recharged and therefore prevented proper well development. Groundwater was only able to be sampled one time (unfiltered metals – April 2002).

1.2.4 Downgradient Wells

Bedrock monitoring wells assessing contaminant migration away from an area of concern and PBOW property are called "downgradient perimeter monitoring wells". These include bedrock wells BED-MW17 and BED-MW18 (downgradient from TNTA), BED-MW15 (downgradient from PRRWP), BED-MW19 (downgradient from WARWP/Acid Area No. 2/PBOW property), and BED-MW22 and former BED-MW27 (downgradient from Pentolite Area/PBOW property). At the public's request, monitoring well BED-MW27 was closed due to obnoxious hydrogen sulfide odors (rotten egg) by the USACE in January 2003 in accordance with Ohio Environmental Protection Agency (OEPA) well closure guidelines.

It is important to note that these perimeter wells represent groundwater impacts from a number of PBOW source areas. These perimeter wells represent the affects of natural attenuation on analytical concentrations and provide an indication of current exposures at the perimeter boundary. As noted in Section 1.2.1.1, background groundwater analytical results are compared to RBSCs.

At TNTA, during the dry season sampling event in October 2001, only 2,6-DNT (0.30 µg/L) was detected in the nitroaromatic analyses and only in well BED-MW17. Nitroaromatics above RBSCs were not detected in well BED-MW19 at WARWP/Acid Area No. 2. In well BED-MW15, only TNT was reported at 1.6 µg/L, below the RBSC of 1.82 µg/L.

Three nitroaromatics were detected in the downgradient perimeter wells BED-MW22 and BED-MW27 in October 2001. Groundwater from well BED-MW22 was detected with 2,4,6-TNT below the RBSC while nitroaromatics 2,4-DNT and 2,6-DNT were detected above RBSCs in well BED-MW27. Both of the sampled bedrock wells exhibited detectable concentrations of VOCs and SVOCs during the October 2001 sampling event. In BED-MW22, the RBSC was exceeded by benzene, while BED-MW27 exhibited acetone, benzene, methylene chloride, toluene, total xylenes, 2-methylnaphthalene, and naphthalene at concentrations above the RBSCs. Four metals were detected in the unfiltered and filtered groundwater samples in well BED-MW22, but only barium exceeded RBSCs in the total and dissolved phases. Ten metals were detected in the unfiltered and filtered groundwater samples from well BED-MW27. Arsenic, iron, and manganese exceeded RBSCs in the unfiltered phase while only manganese exceeded the RBSC in the filtered phase.

During the wet season April 2002 sampling event at TNTA, only 2-nitrotoluene and 3-nitrotoluene were detected at concentrations below RBSCs. Only one nitroaromatic, RDX (0.17 µg/L), was reported in well BED-MW19 at the WARWP/Acid Area No. 2 below the RBSC. In well BED-MW15, 4-A26-DNT (0.97 µg/L) and nitrobenzene (0.35 µg/L) were detected above RBSC levels. Two nitroaromatics (2,4-DNT and 2,6-DNT) were again detected above RBSCs during the April 2002 sampling event in well BED-MW27. Only BED-MW27 exhibited several detectable concentrations of VOCs and SVOCs during the April 2002 sampling event. In BED-MW22, the RBSC was exceeded by methylene chloride only. Well BED-MW27 exhibited acetone, benzene, methylene chloride, toluene, total xylenes, 2-methylnaphthalene, and naphthalene above the RBSCs. Five metals were detected in the unfiltered and filtered groundwater samples in well BED-MW22, but only barium exceeded the RBSC in the total and dissolved phases. Eleven metals were detected in the unfiltered and filtered groundwater

samples from well BED-MW27. Chromium, iron, and manganese exceeded RBSCs in the unfiltered phase while arsenic and manganese exceeded the RBSCs in the filtered phase.

Groundwater sampling results from October 2001 and April 2002 indicated that nitroaromatics have impacted the bedrock groundwater in perimeter monitoring well BED-MW27. The nitroaromatics detected (2,4-DNT, 2,6-DNT, and 2,4,6-TNT) and their concentrations in the perimeter bedrock wells BED-MW27 are similar to those reported in the source area wells. VOC and SVOC compounds acetone, benzene, methylene chloride, toluene, total xylenes, 2-methylnaphthalene, and naphthalene were detected above RBSCs on both occasions in well BED-MW27. Benzene and methylene chloride were detected above RBSCs in well BED-MW22. Several unfiltered and filtered metals were detected in both wells, but only barium in well BED-MW22 and manganese in well BED-MW27 were above RBSCs in both the filtered and unfiltered phases.

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 previously collected data, the overburden thickness within the TNT areas is generally less than 10 feet at TNTA and less than 15 feet at TNTC. The water-producing capacity of the overburden materials is strongly controlled by seasonal changes, and the overburden water-bearing zone is, therefore, not considered to be a source of potable water. The bedrock unit consists of Devonian limestone and shale that 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. The groundwater flow regime in the overburden unit shows a strong seasonal variation (IT, 1999).

2.0 Scope of Work and Objectives

2.1 Scope of Work

As specified in the scope of work (USACE, 2003a), RI activities for the background and off-site downgradient groundwater evaluation will consist of the following tasks:

- Preparation of this site-specific addendum to the site-wide SAP and safety and health plan
- Monitoring well installation
- Monitoring well development and in-situ permeability determination
- Groundwater sampling
- Soil sampling
- Laboratory analysis of soil and groundwater samples
- Management and disposal of investigation-derived waste (IDW)
- Preparation and submittal of a geographic information system deliverable
- Preparation and submittal of report of findings.

2.2 Objectives

The primary objective of the continued RI is to determine the background (upgradient) soil and groundwater quality and the extent of potential COCs in groundwater downgradient of the PBOW facility. In addition, to support ongoing evaluations of potential PBOW source areas, background concentrations of chemicals and inorganics in soil will also be determined. Specific objectives of the continued RI are summarized as follows:

- Define site physical features and characteristics (aquifer background conditions).
- Evaluate fate and transport pathways (groundwater modeling).
- Define current and future routes of exposure.

Sufficient groundwater information will be collected to support the site-wide groundwater modeling under development.

2.3 QAPP Review

The site-wide quality assurance project plan QAPP (IT, 1996c), referenced throughout this work plan, was reviewed for accuracy. Several changes were noted between current analytical methods and sampling procedures and those presented in the 1996 QAPP. The following table summarizes outdated sections of the QAPP and sections of the current SSAP that reflect the QAPP modifications.

Subject	1996 QAPP	2003 SSAP
Analytical Methods	Table 1.1 – Analytical methods are not current and are incomplete.	Table 3-2 provides updated analytical methods.
Analytical Laboratory	Section 2.6 Quanterra is referenced as the laboratory for off-site analysis.	Chapter 5.0 lists STL Knoxville as the primary laboratory.
Data Validation	Section 2.7 – STEP, Inc. is listed as the subcontractor that will perform data validation.	Data validation will be performed by Shaw Environmental, Inc. or a qualified subcontractor.
Decontamination	Section 4.2.4 - Methanol is listed as the solvent for equipment decontamination.	Section 4.3 states that isopropyl alcohol will be used for equipment decontamination.
Sampling ID	Section 4.3 – Designation of SS for soil screening sample type and SO for other soils.	Section 4.1 uses SS for surface soils and SB for soil borings.
Sample Containers	Section 4.9.4 - VOC containers for soil are incorrect (EnCore® samplers required).	Only applicable for VOC analysis. VOCs not collected under this investigation.
Split Samples	Section 4.9.6 - The USACE laboratory will not be analyzing QA samples.	Chapter 5.0 lists Accutest as the QA laboratory.
Container Requirements	Table 5-1 - Container requirements are missing for new methods.	Table 5-1 provides updated sample container requirements for all methods.
Analytical Methods	Tables 7-1 through 7-5 - Analytical methods are outdated or incomplete.	Table 5-1 provides updated analytical methods for all parameters.
Analytical Methods	Table 7-4 – Parameter list for 8330 has changed.	2-amino-4,6-dinitrotoluene and 4-nitrotoluene will be included in the parameter list.
Blank Evaluation	Section 8.4 – Indicates that Contract Laboratory Program (CLP) functional guidelines are used for blank evaluation.	Reference to blank evaluation is not present in the SSAP. Blank evaluation will be completed in the RI report and will follow Region III guidelines.

CLP - Contract Laboratory Program
ID – Identification
QA - Quality assurance
SB - Soil boring
SO - Other soils
SS - Soil screening sample/or surface soil
STL - Severn Trent Laboratory

2.4 Site-Specific Data Quality Objectives

2.4.1 Overview

The data quality objectives (DQO) process followed during the planning stages of the RI evaluated data requirements needed to support the decision-making process and selected the best action to satisfy these requirements. Incorporated components of the DQO process, described in the EPA publication 9355.9-01 *Data Quality Objectives Process for Superfund* (EPA, 1993), are discussed in detail in Section 3.3 of the SAP. Determining factors for procedures necessary to satisfy investigative objectives and to establish the basis of future actions at PBOW are presented in Figure 3-2 of the SAP (IT, 1996a).

2.4.2 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 being 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.

2.4.3 Conceptual Site Model

Four factors considered in defining the conceptual model (USACE, 2003b) for the RI are:

- Potential contaminant sources
- Migration pathways
- Potential receptors
- Contaminants of concern

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 production and associated disposal activities. The migration pathways for potential contaminants include bedrock groundwater, soil, sediment, and surface water runoff to creeks. Likely receptors at PBOW are limited to wildlife and aquatic organisms in creeks. Exposure of humans to potential contaminants under current land use at PBOW is unlikely, since the site is a secure NASA research station. Potential receptors near the facility include off-site water users. Chemicals of potential concern, based on past use of the site, should primarily be nitroaromatic explosives, but may also include VOCs, SVOCs, metals, pesticides/PCBs, and cyanide.

2.4.4 Decision-Making Process, Data Uses, and Needs

The decision-making process, presented in detail in Section 3.3.3 of the SAP (IT, 1996b), consists of a seven-step process that will be followed during the RI (IT, 1996a). Data uses and needs are summarized in Table 2-1. Figure 2-1 presents the order in which samples will be collected and organized.

2.4.5 Risk Evaluation

Confirmation of contamination during the RI will be based upon a comparison of detected contaminants in samples from this investigation to the most current RBSCs. Soil and groundwater RBSCs are derived from EPA (2002) tap water criteria. The RBSCs are based on a generalized residential drinking water scenario, assumed to be the most restrictive use of groundwater. EPA definitive data will be used to determine whether the established guidance criteria are exceeded in the media. Definitive data will be adequate for confirming the presence of the contamination and for supporting a risk assessment and FS, if necessary.

2.4.6 Data Quality, Types, and Quantities

Groundwater and soil samples will be collected and analyzed to meet the objectives of the continued RI. Quality assurance (QA)/quality control (QC) samples will be collected for all sample types as described in Section 3 of this SSAP. 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 characterization and risk assessment.

2.4.7 Precision, Accuracy, and Completeness

Laboratory requirements of precision, accuracy, and completeness for all samples generated during the RI are provided in Section 12.0 of the QAPP (IT, 1996c).

3.0 Field Activities

The continued RI approach will be consistent with work conducted previously at the PBOW facility (IT, 2001e). Field activities associated with the RI at the PBOW facility include the installation and development of 7 bedrock wells, collection and analysis of 10 background soil samples, confirmation analysis for samples from 6 (2 new and 4 existing) background bedrock monitoring wells and 8 (5 new and 3 existing) downgradient bedrock monitoring wells. Permeability testing, subsurface lithologic soil sampling, land surveying, and IDW management will also be performed with the newly installed bedrock monitoring wells.

3.1 Soil Sampling Locations

Locations of soil borings and monitoring wells have been selected by the USACE in conjunction with Ohio EPA. Legal Right-of-Entry documentation will be acquired by the USACE for all monitoring well and soil sampling locations. Shaw will obtain any necessary utility clearances prior to drilling and soil sample collection.

A total of 10 soil samples will be collected from 10 upwind sampling locations. These locations have been selected by the USACE in areas that appear to be unaffected by human activities (i.e. agricultural) and former DOD activities (e.g. native wooded areas). Requirements for background surface soil sample locations are 1) at least 15 feet off existing roadways 2) away from bermed areas 3) away from areas receiving road runoff and 4) undisturbed areas (e.g. forested) or areas that have not been recently disturbed.

3.2 Sampling Methodology and Procedures

The objective for collection of the background soil samples is to obtain a minimum of 10 surface soil samples from the region around PBOW to evaluate the regional occurrence of PAHs in surface soil. The data will be used post-risk assessment and during decision making before and during an FS. The off-site background samples will be collected from a depth of 0 to 1 foot below ground surface, similar to the depth of collection of previous on-site surface soil samples.

The following sampling methods and operational procedures have been developed to ensure that the data acquired through field sampling will meet the DQOs stated in Section 2.4. All soil and bedrock samples (background and well installation samples) collected by Shaw field personnel will be documented through the use of drilling borelogs (USACE Eng. Form 5056-R and 5056A-R). Soil samples that are collected for chemical analysis (background samples only) will be documented by sample collection logs and analysis request/chain-of-custody record forms (Figures 4-16 and 6-2 of the SAP [IT, 1996a]), following field custody procedures specified in

Section 5.1 of the QAPP (IT, 1996c). Any changes from the work plans will be recorded in chronological order in the variance log shown in Figure 9-1 of the SAP (IT, 1996a).

A Shaw geologist will collect the background soil samples, supervise the drilling of each monitoring well borehole, and will maintain a record of the drilling and soil conditions encountered. The geologist will maintain continuous, detailed subsurface logs from examining drill cuttings, recording samples/cores, and noting first-encountered and static groundwater levels for each borehole. Daily field notes will be kept on a Field Activity Daily Log and will include sufficient information to reconstruct the progress of drilling operations, problems encountered, well installation procedures, etc. After completion of database entry, all field forms and documents will be archived in the project files at the Shaw office in Knoxville, Tennessee. A copy of borelogs and well construction logs will be included in an appendix of the final report.

3.2.1 Soil Sampling

3.2.1.1 Lithologic Sampling

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

3.2.1.2 Analytical Sampling

Surface soils in the 10 upgradient (prevailing upwind), background areas will be collected for chemical analysis by means of hand augers, shovel or hand trowel methods. Soil samples will be analyzed for target analyte list (TAL) metals, PAHs, and nitroaromatics. A soil boring log will be completed at each borehole during soil sample collection. All surface soil samples will be visually inspected and logged on the hazardous, toxic, and radiologic waste drilling log (Figure 4-11 of the SAP) by the geologist/geotechnical engineer, using the USCS. After a lithologic record of the soil is made, the soil will be placed into a decontaminated stainless-steel bowl. To obtain a sufficient volume to fill all of the sample jars, it may be necessary to collect additional soil. If additional soil volume is needed, another boring will be completed immediately adjacent to the original location, to the same depth as the first sample. When a sufficient soil volume has

been collected, the soil will be homogenized and transferred to appropriate sample jars, beginning with the jar(s) for nitroaromatic analysis and then placed on ice.

Upon completion of the boring, the hole will be backfilled with any remaining soil and either bentonite/cement or granulated bentonite.

3.2.2 Rock Core Logging

As noted in Section 3.2.1.1, rock core sampling will be continuous for the entire drilling procedure during the monitoring well installation. A rock core bit cutting a maximum 6-inch OD borehole and a rock core tube 5 feet in length will be used for each bedrock monitoring well borehole. If necessary, the bedrock borehole may also be reamed with a rotary bit to attain a 6-inch outside diameter borehole. Upon removal of the rock core tube, measurement of the rock core recovered compared to the run length (length of bedrock drilled) will be made. If the rock core length does not match the run length, total depth of the borehole will be measured to determine if the rock core was lost or washed away. Mention of the lost core on the borelog will be made. Fractures (mechanical, natural, or healed) will also be included on the borelog.

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

3.3 Groundwater

3.3.1 Monitoring Well Locations and Rationales

Seven bedrock, two-inch diameter monitoring wells will be installed on private or government property outside of NASA's perimeter security fence. The approximate locations of 2 of the bedrock wells have been determined and are shown on Figure 1-7. These two wells shown on Figure 1-7 will monitor groundwater coming onto PBOW (background wells). Note these locations may change slightly based on right-of-entry agreements. The locations of the remaining 5 wells will be determined after additional data evaluation. The 2 new off-site background bedrock wells are intended to determine the concentration of certain organic and inorganic constituents in the groundwater as a result of non-PBOW sources. In addition, water level data from these wells will be used to refine groundwater flow directions and help determine

where best to install the remaining 5 off-site bedrock wells. The intent of the 5 off-site downgradient wells is to determine the full rate, extent, and concentrations of constituents of concern in the bedrock saturated zone downgradient from PBOW (USACE, 2003a). The estimated depths for each new and relevant existing well are presented in Table 3-1. Identification of new monitoring wells will be unique and follow sitewide convention established in previous investigations.

3.3.2 Monitoring Well Installation

New monitoring wells will be installed in the bedrock water-bearing zone. Borings for the installation of the wells will be advanced in the residual soils using hollow-stem auger drilling methods or other appropriate drilling methods.

After completion of soil borings, well installations will be performed in conformance with USACE geotechnical requirements. Representative samples of graded filter pack material will be evaluated, and the filter sand will be selected before drilling. The well will be constructed by placing a 1-foot layer of sand in the borehole below the screen and bringing the filter pack to 3 to 5 feet above the top of screen. Screen lengths for the wells will be a minimum of 10 feet in length. Prior to the installation of the bentonite seal, predevelopment of the monitoring well will be performed (see Section 3.3.3). A 3- to 5-foot thick bentonite pellet seal will be placed above the sand pack, depth permitting, and the remaining annular space between the top of the seal and ground surface will be grouted continuously from the top of the bentonite seal to approximately 2 feet bgs. The type of grout to be used will be bentonite-cement slurry grout with about 5 percent bentonite powder and 95 percent Type II or V Portland Cement, mixed with 5 to 7 gallons of clean water per 94 pound sack of cement.

A pre-painted fluorescent yellow 5-foot length of protective, clean steel casing with a locking cap will be installed over the well pipe to a depth of approximately 3 feet bgs. As an alternative method, the isolation casing may be cut approximately 2.5 feet above the ground surface and will be used as the protective casing. If the isolation casing is used, a minimum 6 5/8-inch outside diameter (OD), lockable, well lid will be attached. As frost heave prevention for the surface pad, an internal bentonite collar will be placed within the protective casing and outside the polyvinyl chloride (PVC) well casing to a height of 0.5 feet above ground surface. Sand will be placed above the bentonite within the protective casing to approximately 0.5 feet below the top-of-casing to prevent the well cap or other objects from falling in. A square concrete pad will be constructed around the well, a minimum of 4 feet square and 4 inches thick, sloping away from the well. An internal drainage hole (weep hole) will be drilled through the steel casing just above the mortar collar. After the grout has thoroughly set, the pre-painted protective steel

casing will be identified by the well number in black. As mentioned, if a 5-foot protective steel casing is used instead of the isolation casing, it will be painted in an area away from the monitoring well, before installation, to prevent possible contamination of well water by the paint. If the isolation casing is used as the protective casing, a flat object will be placed over the top of the casing to prevent any paint from entering the well. Four posts will be set radially around the well, close to the edge of the pad. Completed wells will be surveyed by a licensed land surveyor. A typical monitoring well installation and construction diagram is included as Figure 3-1.

An optional surface protection strategy will be to complete monitoring wells flush with the ground surface. This will be accomplished by terminating the PVC riser at or below ground surface and installing a protective watertight valve box around the riser. The valve box will be set into the grout that surrounds the riser. Grout will also be placed around the valve box to provide positive drainage. The PVC riser will be fitted with a lockable cap. A typical flush mount monitoring well installation and construction diagram is included as Figure 3-2.

A well installation diagram illustrating the depth of the boring, screen location, sand filter pack material, seals, grout, and height above ground surface will be included in the remedial investigation report.

3.3.3 Monitoring Well Predevelopment

Following addition of the filter pack but before addition of the bentonite seal, predevelopment of the monitoring well will be performed. Predevelopment will permit compaction of the filter pack, prevent any bridging of the sand that may have occurred during installation, allow placement of any additional sand needed after predevelopment, and prevent any rock or sand fines from accumulating on the well bottom.

For monitoring well predevelopment, a decontaminated surge block, bailer, or submersible pump will be lowered into the screened interval of the well and groundwater will be manually surged for a 20-minute time period. Surging of groundwater should be performed at different intervals within the entire screened portion of the well during this time. After 20 minutes, 2 volumes of groundwater in the well casing will be removed using either a submersible pump or bailer. The depth of the filter pack shall be re-measured and additional sand added, if necessary. Water quality parameters will not be recorded during the 20 minutes of surging or during the water removal process. Also, the total volume of groundwater removed after the surging process will not be added to the required volume of groundwater to be removed for well development.

3.3.4 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 5 percent of the screen length. If yields permit, the standing water volume in the well (calculated as the volume of water in the well screen and casing and saturated annulus) will be removed at least five times. In addition, if water is used during bedrock drilling, any volume lost will be recorded and 5 times the amount will be removed during development. For each well, a sample of the last water removed during development will be captured and retained for visual inspection and photographing. During development, field measurements of pH, specific conductance, and temperature will be made, and descriptions of the development technique and the physical characteristics of the water (clarity, color, turbidity, and odor) will be recorded by the Shaw geologist. Wells will be developed by pumping, bailing, and surging without using acids, flocculants, disinfectants, or dispersing agents. All purged water will be drummed at the well site. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well. The development procedure will continue until the following conditions are met:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- Thickness of the accumulated sediment in the well is less than 5 percent of the length of the well screen.
- Temperature, pH, specific conductance values stabilize, and three consecutive turbidity readings are less than 100 nephelometric turbidity unit (NTU).
- A volume of water has been removed equal to five times standing water in the well, including the well casing and screen, and the saturated annular space assuming 30 percent porosity.

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

If the groundwater is not clear and free of sand after four hours of well development, the USACE will be contacted for consultation and further instructions. 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 (35-mm color print). The photograph will be submitted as part of the well-development log. The photograph will be a suitably back-lit close-up to show the clarity of the water. The development water sample will be archived until receipt of developed prints.

3.3.5 Development Records

The following records will be kept on a well-development log:

- Project name and location
- Well designation and location
- Date and time of well installation
- Date and time of well development
- Static water level from top of well casing before well development and 24 hours after well development
- Quantity of fluid in well prior to development:
  - Standing in well
  - Contained in saturated annulus, based on an assumed 30 percent porosity
- Field measurements of pH, conductivity, and temperature before, twice during, and after development
- Field measurement of turbidity (NTU) until three consecutive measurements are less than 100 NTUs.
- Depth from top of well casing to bottom of well
- Screen length
- Depth from top of well casing to top of sediment inside well, before and after development
- Physical character of removed water, including changes in clarity, color, particulate, and odor
- Type and size/capacity of pump and/or bailer used
- Description of surge technique
- Measured height of well casing above ground surface at time of development

- Typical pumping rate and estimated well yield
- Quantity of water/fluid removed during development, both incremental and total
- Disposal of development water.

3.3.6 Water Level Monitoring

The depth to water will be measured to the nearest 0.01 foot from the highest point on the riser (inner casing) or from a marking on the riser from which the elevation has been surveyed.

3.4 Groundwater Sampling

Groundwater samples will be collected from certain existing and newly installed monitoring wells (Table 3-1). Proposed and existing background groundwater monitoring well locations are shown on Figure 1-7. Groundwater sampling will be conducted in order from the areas assumed to be least contaminated to the areas assumed to be most contaminated. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. In addition, the condition of all surface components of the monitoring wells sampled will be documented with the recommendation for repair. The surface components will include the concrete pad, protective posts, protective casing, and well casing. In addition, the condition of the well locks and lock hasps will be documented.

3.4.1 Groundwater Sampling Schedule

Following installation of the 2 new off-site background bedrock monitoring wells, the newly installed background wells (BED-MW28 and BED-MW29) with the existing 4 on-site background wells (BG8-BEDGW-001, BED-MW20, BED-MW24, BED-MW25), will be sampled on a quarterly basis for one year. Groundwater samples will be analyzed for target compound list (TCL) VOCs, TCL semivolatiles, TAL metals (filtered and unfiltered), nitroaromatics, and water quality parameters (Table 3-2).

Following installation of the 5 new off-site downgradient bedrock monitoring wells, the newly installed downgradient wells (BED-MW30, BED-MW31, BED-MW32, BED-MW33, BED-MW34) and existing 3 on-site downgradient wells (BED-MW17, BED-MW19, and BED-MW22), will be sampled 2 times on alternate quarters with the background monitoring well sampling. Groundwater samples will be analyzed for TCL VOCs, TCL semivolatiles, TAL metals (filtered and unfiltered), nitroaromatics, and water quality parameters (Table 3-2). The schedule for all PBOW wells sampled under this RI is shown in Table 3-3. This schedule includes the historical samples collected.

3.4.2 Groundwater Sampling Equipment

The equipment required for groundwater sampling includes:

- Water level indicator
- Low-flow submersible pump with Teflon-lined tubing
- Teflon or stainless steel bailer of appropriate size for the monitoring well fitted with a bottom-emptying device
- Nylon rope
- Oxygen reduction potential (Eh), dissolved oxygen, pH, temperature, turbidity, and specific conductance meters
- Appropriate sample bottles and temperature-controlled container
- Plastic sheeting
- Five-gallon buckets with lids
- Photoionization detector (PID)/lower explosive limit (LEL) meter
- Mason jar for calculating purge rate
- Well construction diagrams.

3.4.3 Groundwater Sampling Procedures

Sampling of newly installed monitoring wells will take place no sooner than 14 days after well development has been completed. All equipment used to purge wells and collect samples will be protected from ground surface contact and contamination by use of clean plastic sheeting. Two procedures are available for purging and sampling wells. Low-flow (minimal drawdown) is the preferred purging and sampling method in wells where adequate recharge exists. If wells do not recharge adequately to use low-flow (minimal drawdown) sampling, an alternative method will be used depending on the static water level in the well relative to the well screen. 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 well cap, a PID/LEL meter will be used to measure the concentration of organic vapors and hydrogen sulfide at the top of casing and in the breathing zone. If readings are above background, safety

precautions outlined in the safety and health plan (SHP) will be followed (IT, 1996b).

- The depth to water will be measured using a decontaminated water level indicator, then the volume of water in the well casing and screen and the volume present in the saturated annulus (filter pack) 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 well screen and the well pumped at a rate that minimizes drawdown. Typically, purging rates are on the order of 200 milliliters per minute (ml/min) to 500 ml/min. It is critical that the purge rate be set such that drawdown in the well is never greater than 0.5 feet. Water chemistry parameters (pH, Eh, conductivity, temperature, dissolved oxygen and turbidity) will be monitored for stability.

- If the pre-pumping (static) water level is above the top of the well screen 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 well casing and saturated annulus. In this instance, the water level must not be allowed to drop below the top of the well screen. It is, however, acceptable to pump out the stagnant water in the well casing at a higher purge rate but pumping must be stopped when the water level in the well reaches the top of the well screen. Once at least one well volume is removed, the well may be sampled. It should be noted, however, that attempts will be made to remove more than one well volume of water.

- If the pre-pumping (static) water level is below the top of the well screen 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 well casing and saturated annulus. However, in some wells, recharge may be so low that adequate purging of the well may not be achieved even over a period of days. In this case, the well may be sampled without purging, after consultation with the USACE.

- During purging, field measurement of pH, Eh, temperature, turbidity, dissolved oxygen, and conductivity will be performed. When using low-flow sampling, once these parameters are stable, the well may be sampled. If stability is not achieved after 4 hours of purging, the well will be sampled. Stability is defined as follows:

  - pH +/- 0.1 standard units (SU)
  - Eh +/- 10 mV
  - Temperature +/- 3% degrees Celsius (°C)

- Turbidity (three consecutive readings less than 100 NTUs)
- Dissolved Oxygen +/-1%
- Conductivity +/-3% of reading.

- For slow recharging wells, field parameters will be recorded after sampling.

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

- Immediately after collection of the sample for chemical analysis, a second sample will be collected for field measurement of temperature, pH, Eh, dissolved oxygen, and conductivity.

- Sample containers will be labeled with appropriate identifying information (location, date, time, condition, added preservatives, etc.). The 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 100 ml/min for VOCs. Pumping rates for all other analyses will not exceed 500 ml/min. Samples collected for VOC analysis will be collected first.

- Samples for volatile analysis will be collected in screw-cap, septum-top glass vials, and filled so that there are no air bubbles present to allow volatilization.

- Samples for metals and/or nitroaromatics analysis (as described in the site-specific attachments) will be collected in two separate containers; one will be filtered and the other will not be filtered. Samples will be filtered according to the following procedures:

  - The water sample will be filtered at the well site with an in-line filter.

  - A Millipore filtration apparatus (or comparable equipment) equipped with a 0.45-micron filter will be used. An in-line filter will be used for each well.

- All sample containers will be transferred to a cooler chest (kept at 4 degrees °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.

3.5 Land Surveying

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

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. Note that two mobilizations are planned for surveying. The first mobilization will include surveying soil locations and the initial 2 bedrock wells. The remaining wells will be surveyed after they are installed.

3.6 Field Permeability Testing

Field permeability will be evaluated for new wells installed at the former PBOW by performing a slug test after well development. To avoid altering the groundwater chemistry at the site by the introduction of water, water will be instantaneously displaced by inserting a solid slug. The recovery rate will be recorded, and the data will then be evaluated by the appropriate method to determine in situ hydraulic conductivity. Both falling head and rising head tests will be completed.

3.7 Utility Clearances

Prior to beginning any intrusive investigation (i.e., soil boring, monitoring well installation), all sites must have received a signed right-of-entry and/or a signed lease agreement by the legal property owner. This authorization will be obtained by the USACE and be presented to Shaw prior to fieldwork. Shaw will obtain the underground utility clearance for all public lines prior to field operations. Lines that will be located include telephone, natural gas, underground electric, water, and sewer. Private utility lines located on the private property will not be marked or located by the utility companies. For borings drilled on private property, the land or home owner will be questioned pertaining to knowledge of any underground lines near the drilling location. In addition, the first 4 feet of all boreholes will be post-hole dug, prior to any drilling activities.

3.8 Site Access

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

3.9 Well Abandonment

After the initial sampling of any downgradient monitoring well, if characteristics are similar to former monitor well BED-MW27 (off-gassing of hydrogen sulfide), abandonment may be conducted if requested by the USACE. Abandonment procedures will follow the OEPA and USACE guidelines as listed:

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

- Removal of well material will be attempted. If however, removal of the isolation casing and the well screen/casing is not possible, abandonment in place will be conducted.

- Steel isolation casing and PVC well material shall be cut to approximately 2 feet bgs and surface completion material (guard posts, pad, protective steel casing) removed.

- A concrete/grout mixture will be tremied from the bottom of the well screen 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 if the depth of the unfilled portion of the borehole is more than 15 feet.

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

3.10 Site Cleanup

Prior to driving any equipment or vehicles onto the well site, digital photographs will be taken of the area to serve as a reference for determining how much repair will be necessary after the monitoring well has been installed. Grading of the ground surface, seeding, and covering with straw may be performed, if necessary, to return the area to the original condition.

4.0 Sample Analysis and Decontamination Procedures

4.1 Sample Number System

The sample numbering system to be used during this investigation for fixed-base samples (i.e., samples that are sent to an off-site laboratory) will conform to the USACE-Nashville District's numbering convention. Specifically, each sample will be assigned a unique sample identification number that describes where the sample was collected. Each number consists of a group of letters and numbers, separated by hyphens. The numbering system to be used for the RI is described as follows:

Project Code	Year	Sample Type[a]	Site Identification[b]	Boring Number	Sample Number	Sample Depth[c] (ft)
PBOW	03	XX	XXXX	XXXXX	XXXXXX	XX-XX

ft - feet

[a]Sample types:

BW – Blank water (used for trip blanks and field blanks)
GW – Groundwater sample
SB – Subsurface soil sample
SD – Sediment sample
SS – Surface soil sample
SW – Surface water sample

[b]Site:

TNTA - TNT Area A
TNTB - TNT Area B
TNTC - TNT Area C
WARWP - West Area Red Water Ponds
PRRWP - Pentolite Road Red Water Ponds
BCG – Background.

[c]Depth : Only required for soil samples.

PBOW-00-SB-TNTA-SO001-AB0001-04-06 signifies that this soil sample was collected from a depth of 4 to 6 feet at soil location SO001 in TNTA with a sample number of AB0001. The sample identification number will be recorded by the Shaw field geologist in the field activity daily log, boring log, and sample collection log as shown respectively in Figures 4-1, 4-11, and 4-16 of the SAP (IT, 1996a).

4.2 Analytical Program

The analytical program has been designed to acquire sufficient and defensible data to determine the extent of contamination in the investigated areas. Table 3-2 summarizes the analytical parameters required and associated laboratory methods to be used during this investigation.

A contract laboratory will analyze samples for nitroaromatics, TCL VOCs, TCL SVOCs, TAL metals, and various water quality parameters. 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 (EPA), 1986) and its subsequent updates. They will meet the QA/QC requirements outlined in the EM-200-1-6 *Chemical Quality Assurance for Hazardous, Toxic and Radioactive Waste (HTRW) Projects*. Also, contract laboratories will adhere to QA/QC criteria set forth in the *Shell for Analytical Chemistry Requirements*, Appendix I of the USACE document EM-200-1-3 *Requirements for the Preparation of Sampling and Analysis Plans*. 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 SAP (IT, 1996a) and will be followed during the current groundwater investigation. The Shaw field coordinator must contact Plum Brook Station for access to a potable water source for decontamination use. The following summarizes decontamination procedures for equipment before site entry, between borings, and before site departure:

Nonsampling equipment (augers, drill rod, 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.

Confirmation samples:

- 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 isopropyl alcohol.
- Final rinse with ASTM Type II water; the volume of water used will be at least five times greater than the volume of isopropyl alcohol 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, 1986 [3rd Edition]). 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. Samples will be cooled to a temperature of approximately 4 °C and maintained at that temperature by means of double-bagged ice until the cooler is received at the laboratory. Coolers will be shipped to the laboratory by a next-day delivery service. Notification of shipment, including air bill number, will be telephoned or faxed to the laboratory on the day of sample collection. If this is not possible, the laboratory will be notified the following morning.

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

Severn Trent Laboratory (STL) Knoxville
Attention: Jamie McKinney
5815 Middlebrook Pike
Knoxville, Tennessee 37923
Telephone: (865) 588-6401

STL North Canton (Water Quality Parameters and total organic carbon [TOC] only)
Attention: Ken Kuzior
4101 Shuffel Drive NW
North Canton, Ohio 44720
Telephone: (330) 497-9396

Accutest Laboratories
Attention: Sue Bell
4405 Vineland Road, Suite C-15
Orlando, FL 32811
Telephone: (407) 425-6700.

6.0 Investigation-Derived Waste Management Plan

Anticipated IDW during field activities includes soil (drill cuttings), bedrock cores, purge/development water, decontamination fluid, and disposable personal protective equipment. Detailed procedures for IDW management are provided in Chapter 8.0 of the SAP (IT, 1996a). The following is a brief summary of the procedures for handling IDW.

6.1 Soil and Groundwater

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

6.2 Decontamination Fluid

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

6.3 Sampling Equipment and PPE

Limited quantities of personal protective equipment (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 IDW Sampling

All soil and water IDW will be sampled at the completion of fieldwork. For soils, one composite soil sample will be collected from drummed soil for each well. The composite sample will then be submitted to the identified laboratory for a full toxicity characteristic leaching procedure analysis and nitroaromatics. Seven-day turnaround time will be used, unless otherwise directed by the project manager.

When the analytical results are received, Shaw personnel will evaluate the results and make a determination of off-site disposal methods. Possible disposal facilities will be identified by Shaw; however, selection of the facility or facilities to receive the IDW will be the responsibility of the USACE.

7.0 References

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TABLES

Table 2-1

Summary of Data Quality Objectives
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Potential Data Users	Available Data	Conceptual Model	Media of Concern	Data Uses and Objectives	Data Types	Analytical Level
EPA OEPA DOD USACE NASA Shaw Other Contractors Possible Future Land Users	Previous environmental investigations show varying degrees of contamination in the 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 VOCs, SVOCs, metals, and nitroaromatic explosives	Groundwater 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 VOCs SVOCs Water quality parameters Soil Metals Explosives VOCs SVOCs	Field screen Laboratory screen Definitive Definitive

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.
VOC - Volatile organic compound.
Shaw - Shaw Environmental, Inc.

Table 3-1

Monitoring Well Construction Details
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Wells	Proposed Well ID	Approximate Total Well Depth (feet)	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet)
New Bedrock Background Wells					
Upgradient Boundary, Southeast of well BED-MW20	BED-MW28	70	2	NA	NA
Upgradient Boundary, Southwest of BED-MW25	BED-MW29	50	2	NA	NA
Existing Bedrock Background Wells					
BG8-BEDGW-001	NA	20	2	6	15
BED-MW20	NA	49.5	4" to 35 2" to 48.5'	12" to 35' 3" to 49.5'	20
BED-MW24	NA	41	2	6	15
BED-MW25	NA	38	2	6	15
New Downgradient Bedrock Wells					
West of well BED-MW24	BED-MW30	75	2	NA	NA
North of PBOW facility	BED-MW31	75	2	NA	NA
	BED-MW32	75	2	NA	NA
	BED-MW33	75	2	NA	NA
	BED-MW34	75	2	NA	NA
Existing Downgradient Bedrock Wells					
BED-MW17	NA	64.4	4	3 (A)	45 (B)
BED-MW19	NA	49.5	4	3 (A)	32 (B)
BED-MW22	NA	42	2	6	15

A - 3-inch diameter open borehole into bedrock.
B - Length of open borehole.
ID - Identification.
NA - Not available.
PBOW - Plumbrook Ordnance Works.
Depths for proposed wells are estimated.

Table 3-2

Summary of Analytical Parameters and Methods
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters[a]	Analytical Method[b]
Groundwater	TCL Volatile Organic Compounds	SW-846 5030B/8260B
	TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
	Nitroaromatic Compounds	SW-846 3535/8330
	TAL Metals (T/D)	SW-846 3005A/6010B/7470A
	Turbidity	EPA 180.1
	Alkalinity	EPA 310.1
	Hardness	EPA 130.2
	Total Organic Carbon	SW-846 9060
	Total Dissolved Solids	EPA 160.1
	Total Suspended Solids	EPA 160.2
	Chloride	EPA 325.3
	Cyanide, total	SW-846 9010A/9012
	Nitrate	EPA 350.2
	Sulfate	EPA 375.3
Soil	Polynuclear Aromatic Hydrocarbons (PAH)	SW-846 3540C/8310[c]
	Nitroaromatic Compounds	SW-846 8330
	TAL Metals	SW-846 3050B/6010B/7471A
Soil IDW	TCLP Volatile Organic Compounds	SW-846 1311/5030B/8260B
	TCLP Semivolatile Organic Compounds	SW-846 1311/3510C/8270C
	TCLP Metals	SW-846 1311/3005A/6010B/7470A
	Ignitability	SW-846 1010
	Corrosivity	SW-846 1110
	Reactivity	7.3.3.2/7.3.4.2

[a]Target analyte list (TAL) and target compound list (TCL) are used to designate parameter lists with no requirements for Contract Laboratory Program (CLP) 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]The 8310 parameter list includes: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, bennnzo(k)fluoranthene, chrysene, dibennz(ah)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, phenanthrene, pyrene, naphthalene

IDW - Investigation-derived waste.
T/D - Total/dissolved.
TCLP - Toxicity characteristic leaching procedure.

Table 5-1

Analytical Methods, Containers, Preservatives, and Holding Times
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater	TCL VOCs	SW-846 5030B/8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(1) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Total 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)
	Dissolved 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)
	Hardness	EPA 130.2	(1) 250 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
	TOC	SW-846 9060	(2) 40 ml VOA vial	Cool to 4°C, H_2SO_4 to pH <2	28 days
	Cyanide, total	SW-846 9010A/9012	(1) 1 L HDPE	Cool to 4°C, NaOH to pH >12	14 days
	Turbidity	EPA 180.1	(1) 1 L HDPE	Cool to 4°C	48 hours
	Alkalinity	EPA 310.1			14 days
	Total Dissolved Solids	EPA 160.1			7 days
	Total Suspended Solids	EPA 160.2			7 days
	Chloride	EPA 325.3			28 days
	Nitrate	EPA 350.2			48 hours
	Sulfate	EPA 375.3			28 days
Soil	Nitroaromatics	SW-846 8330	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction/40 days
	TAL Metals	SW-846 3050B/6010B/7471A			6 months (28 days for Hg)
	PAHs	SW-846 3540C/8310			14 days extraction/7 days/40days

Table 5-1

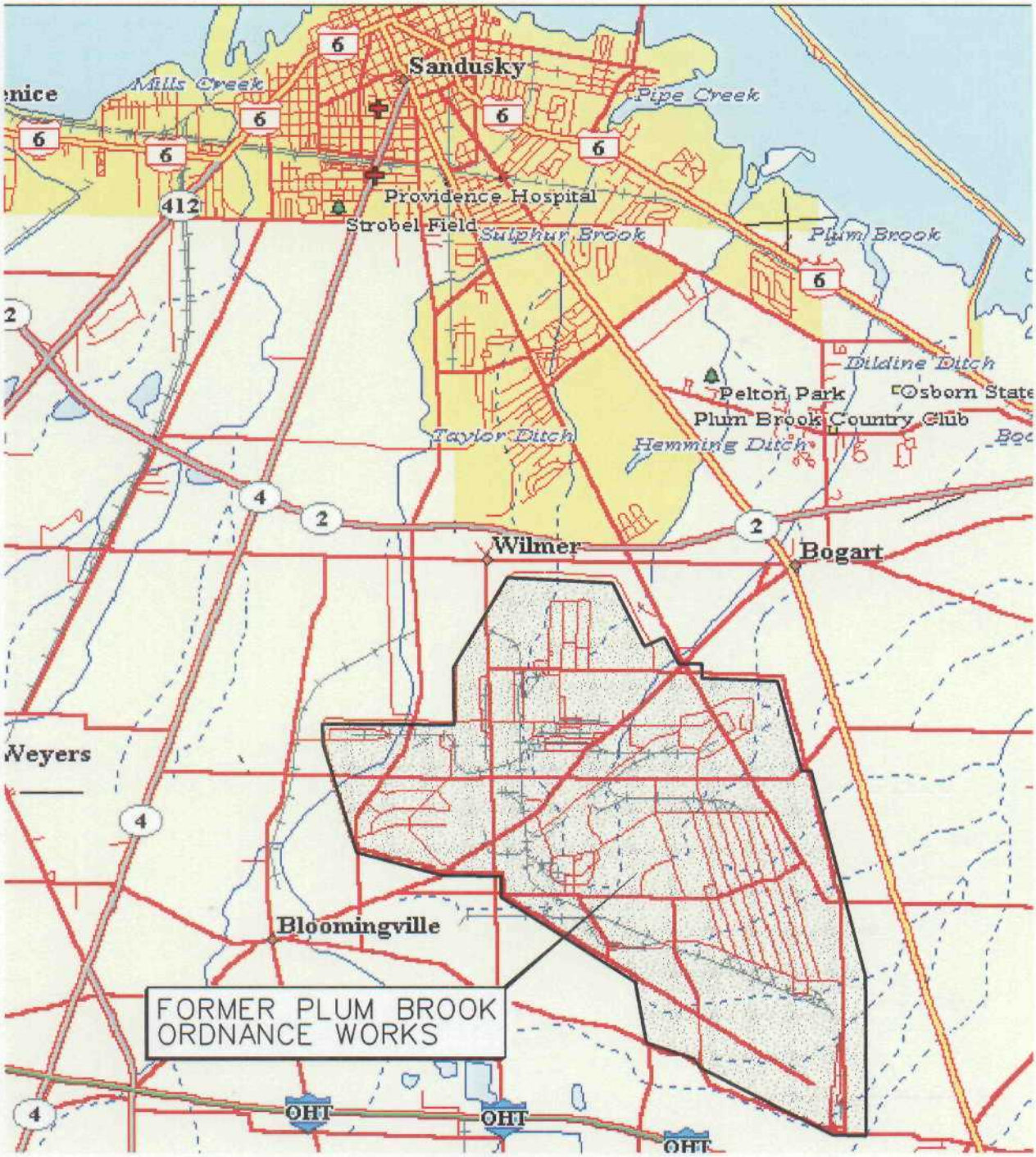
Analytical Methods, Containers, Preservatives, and Holding Times
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

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 1311/3005A/6010B/7470A			14 days /ext./6 months (28 days for Hg)
	Ignitability	SW-846 1010			ASAP
	Corrosivity	SW-846 1110			ASAP
	Reactivity	7.3.3.2/7.3.4.2			ASAP

°C - Degrees Celsius.
CWM - Clear wide mouth.
H_2SO_4 - Sulfuric acid.
HCl - Hydrochloric acid.
HDPE - High density polyethylene.
Hg - Mercury.
HNO_3 - Nitric acid.
L - Liter.
mL - Milliliter.
NaOH - Sodium hydroxide.
PAH - Polynuclear aromatic hydrocarbon.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TOC - Total organic compound.
VOC - Volatile organic compound.
IDW - Investigative-derived waste.
EPA - U.S. Environmental Protection Agency.
VOA - Volatile organic analysis.
OZ - Ounces.
Ext. - Extraction
ASAP - As soon as possible.

*Number of containers required in ( ).

FIGURES



NOT TO SCALE

FIGURE 1-1
VICINITY MAP

FORMER PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. 843656-pbow-ssap-0001.dgn
PROJ. NO.: 843656
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWNEY
INITIATOR: N.SIREK
CADD REVIEW: C.BENTLEY
STARTING DATE: 08MAY03
DRAWN BY: C.TUMLIN
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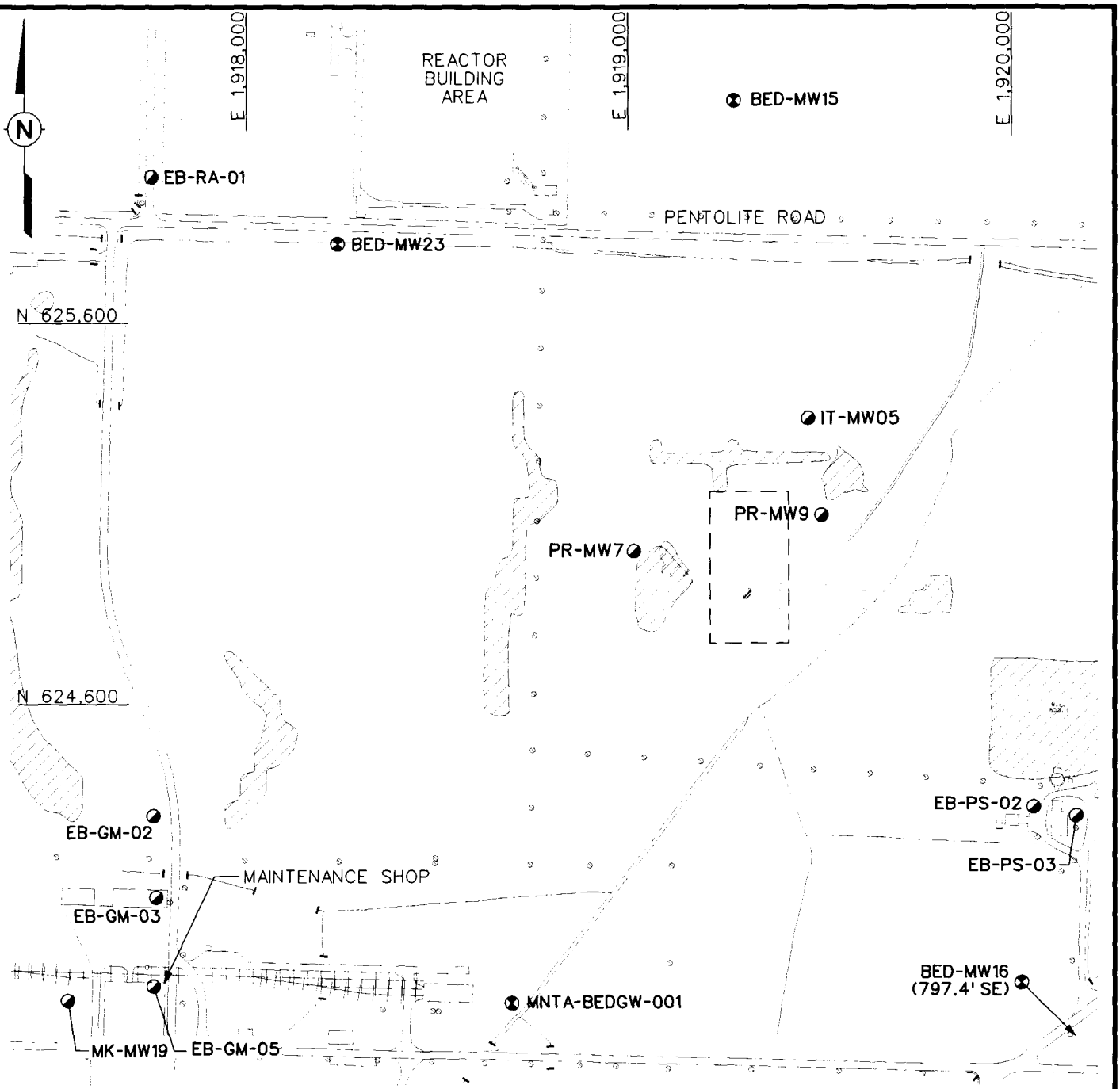


LEGEND

- BUILDINGS
- RAILROAD
- SURFACE WATER
- SURFACE WATER DRAINAGE
- APPROXIMATE HISTORICAL LOCATION OF PONDS
- FENCE (PBOW BOUNDARY)
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

SCALE

0 400 800 FEET

FIGURE 1-6
PENTOLITE ROAD RED WATER PONDS - BEDROCK WELL LOCATION MAP

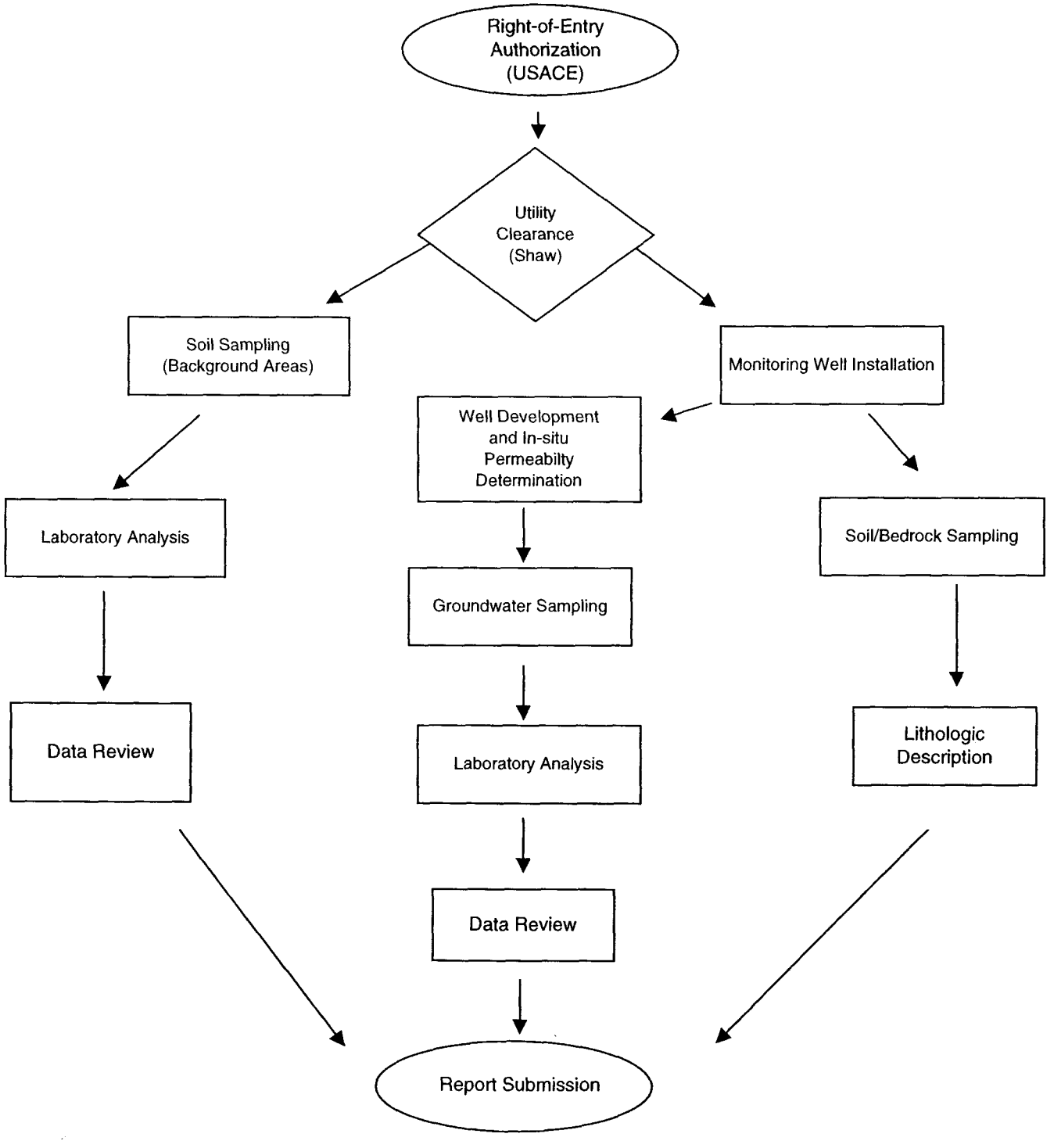
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

STARTING DATE: 12MAR03 | INITIATOR: JKESSLER | TECH. REVIEW: DKESSLER | DWG: 843656 pbow ssap 0006.dgn
DRAWN BY: ETUMLIN | CADD REVIEW: CBENTLEY | PROJ. MGR.: SDOWNES | PROJ. NO.: 843656

Figure 2-1

Investigation Flow Chart
Continued Groundwater Remedial Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio



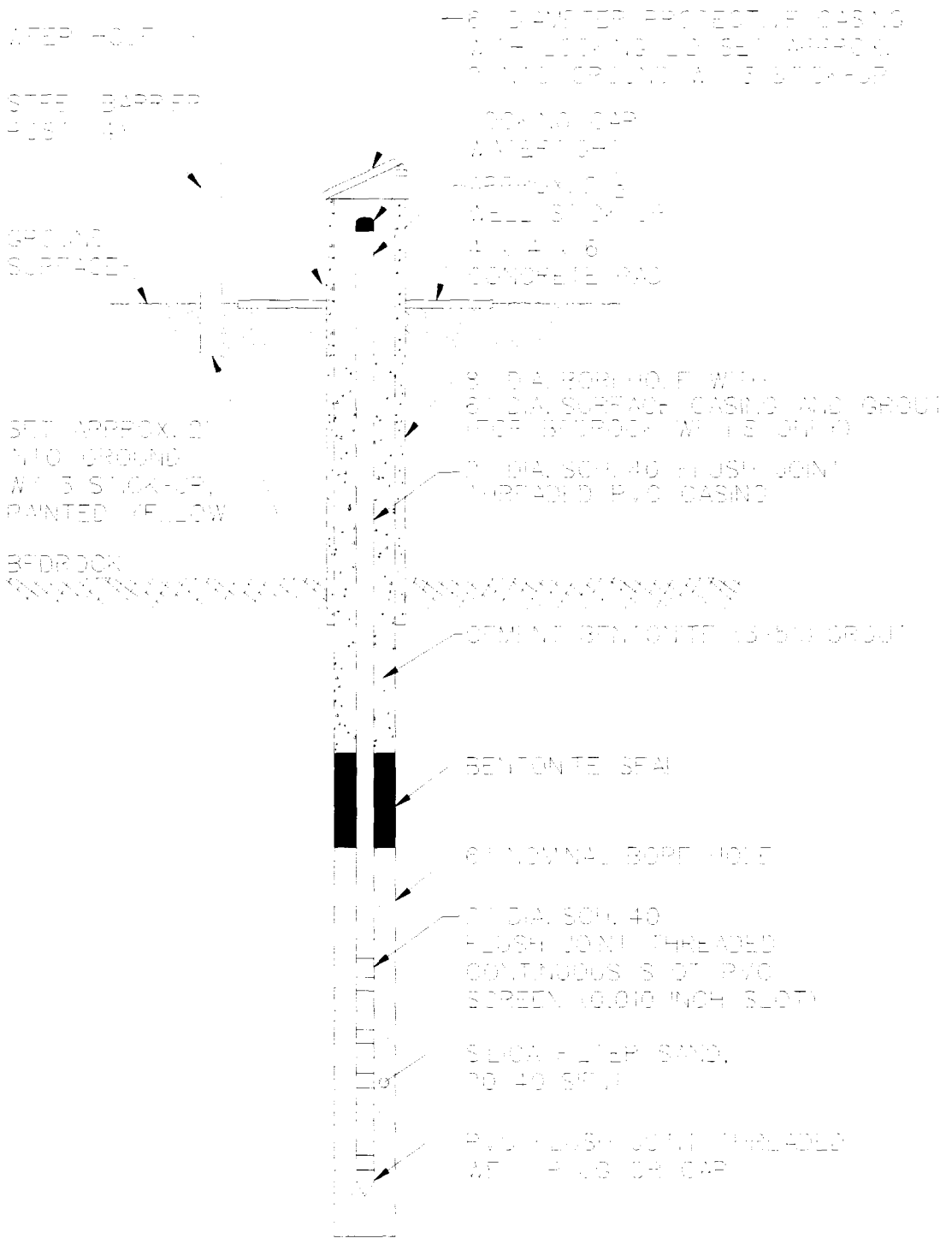


FIGURE 3-1

TYPICAL ABOVE GRADE MONITORING WELL INSTALLATION AND CONSTRUCTION DIAGRAM

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

STARTING DATE: 12MAR03 | INITIATOR: DAESSLER | TECH. REVIEW: DAESSLER | DWG: 84-9656-pbow-ssap-000.dgn
DRAWN BY: C. JMN | CADD REVIEW: CBENNETT | PROJ. MGR.: SUDWARD | PROJ. NO.: 84-9656

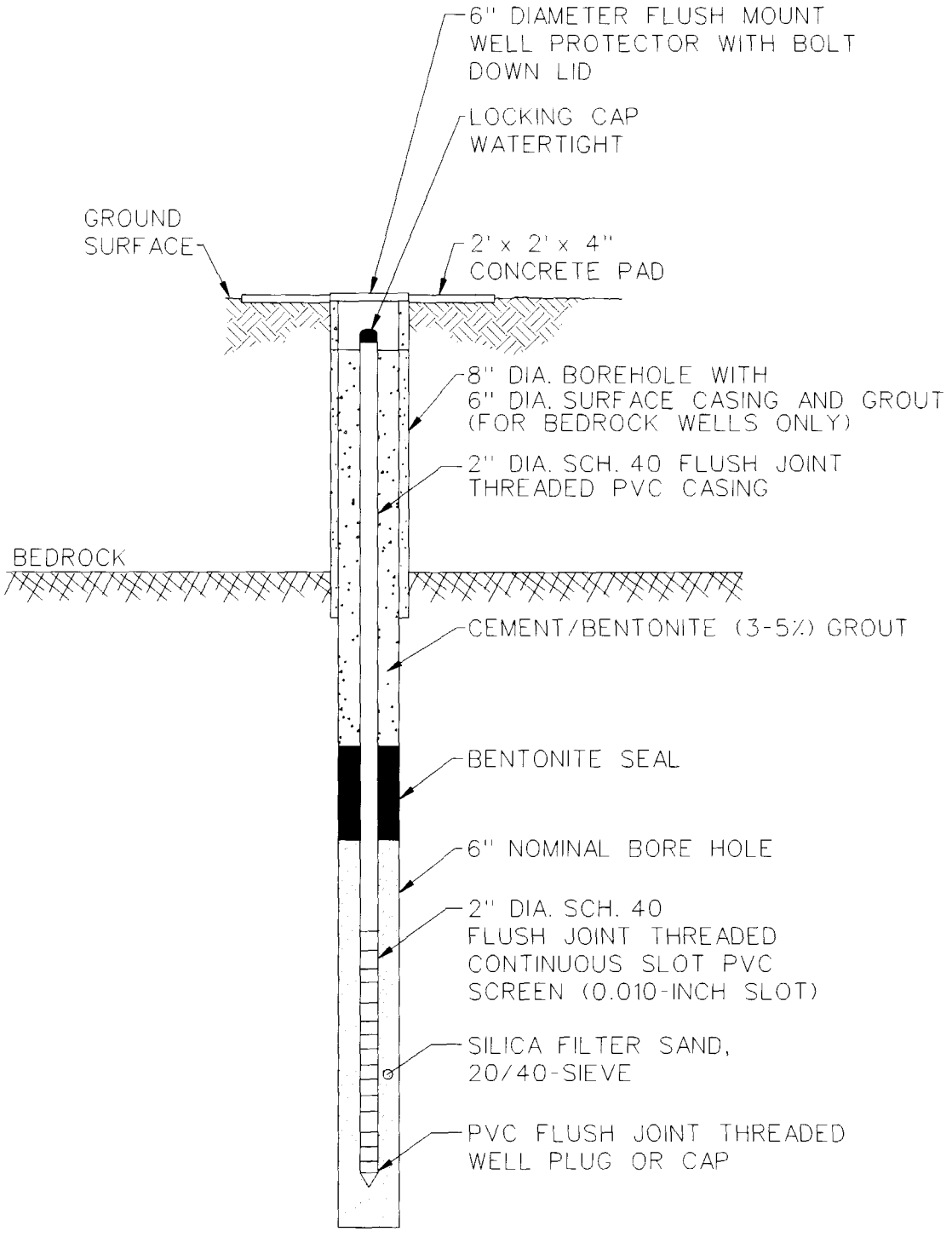


FIGURE 3-2

TYPICAL FLUSH MOUNT MONITORING WELL INSTALLATION AND CONSTRUCTION DIAGRAM

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. 843656-pbow-ssap-0010.dgn
PROJ. NO.: 843656
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWNEY
INITIATOR: D.KESSLER
CADD REVIEW: C.BENTLEY
STARTING DATE: 14MAY03
DRAWN BY: C.TUMLIN
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0.083 ft / IN.
dhall
843656-pbow-ssap-0010.dgn

Shaw Shaw Environmental, Inc.

DISCIPLINE SIGN-OFF REVIEW

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

Project Description: Continued Groundwater Remedial Investigation, Background and Off-Site Downgradient Groundwater, Former Plum Brook Ordnance Works, Sandusky, Ohio

Contract No. DACA62-00-D-00002 Delivery Order No. 0010

Project No. 843656 Task/Phase Number: 02000000

Document Type	Identify specific section or segment covered by this checkprint	Document Origin
☐ Technical / Cost Proposal		☐ Originator Developed
☐ RFP		X Edited Standard
☐ Contract / Subcontract		☐ Client Furnished
X SHP, SSAP, CDAP, or QAPP	Site-Specific Health and Safety Plan	
☐ Report		**Document Status**
☐ Risk Assessment / Evaluation		☐ Preliminary
☐ Specifications & Plans		☐ Internal Draft
☐ Design Calculations		☐ Draft
☐ Tables		☐ Draft Final
☐ Drawings / Figures		X Final
☐ Other:		☐ Other:

	Required Person	Discipline	Signature	Date
Originator	William Hetrick	CIH	William Hetrick	7/22/03
Checker	David Kessler	Geologist	David Kessler	7/23/03
Peer Review	David Duncan	CIH	David H. Duncan	7/22/03
Technical Review	Michael Gunderson	Geologist	M J Gunderson	7/24/03
Technical Review	Steven Downey	Engineer	Steven T Downey	7/24/03
Quality Assurance Manger	Mary Hall	Quality Assurance	Mary M Hall	7/24/03
Project Manager	Steven Downey	Engineer	Steven T Downey	7/24/03

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

Attachment XI

Site-Specific Health and Safety Plan
Continued Groundwater Remedial Investigation
Background and Off-Site Downgradient Groundwater

Former Plum Brook Ordnance Works
Sandusky, Ohio

Prepared by:

Shaw Environmental, Inc.
312 Directors Drive
Knoxville, Tennessee 37923

Submitted to:

Commander
U.S. Army Engineer District, Nashville
Post Office Box 1070
Nashville, Tennessee 37202-1070

Shaw Project No. 843656

July 2003

Revision 1

This Site-Specific Safety and Health Plan Attachment must be used in conjunction with the Sitewide Safety and Health Plan for Site Investigations and Groundwater Investigations at the former Plum Brook Ordnance Works, dated July 1997.

The following SSHP has been designed for the methods presently contemplated by the company for execution of the proposed work. Therefore, the SSHP may not be appropriate if the work is not performed by or using the methods presently contemplated by the company. In addition, as the work is performed, conditions different from those anticipated may be encountered and the SSHP may have to be modified. Therefore, the company only makes representations or warranties as to the adequacy of this SSHP for currently anticipated activities and conditions.

Reviews and Approvals

I have read and approve this Site-Specific Safety and Health Plan for Continuing Groundwater Remedial Investigations, Background and Off-Site Downgradient Groundwater with respect to project hazards, regulatory requirements, and Shaw procedures.

Steve Downey, Project Manager
Shaw Environmental, Inc.

7/23/03
Date

William J. Hetrick, Health and Safety Manager, CIH
Shaw Environmental, Inc.

7/22
Date

THE AMERICAN BOARD OF INDUSTRIAL HYGIENE
INCORPORATED
CERT. NO. 1105 C
EXPIRES 12-31-2003
PENNSYLVANIA - 1960
WILLIAM J. HETRICK, CIH

David Kessler, Site Coordinator
Shaw Environmental, Inc.

7/23/03
Date

Site Safety and Health Officer
Shaw Environmental, Inc.

7/23/03
Date

Site Health and Safety Plan Acknowledgment

I have read, understand and agree to abide by the provisions as detailed in this site-specific safety and health plan prepared by Shaw for the continued groundwater remedial investigation at the Former Plum Brook Ordnance Works, Sandusky, Ohio. Failure to comply with these provisions may lead to disciplinary action and/or my dismissal from the work site.

Printed Name	Signature	Employee Number	Date

Plum Brook Project Emergency Contacts

Note: When field crews are on NASA property, they may be provided with 2-way radios from the Communications Center. In the event of any emergency, **contact the Plum Brook Communications Center** by radio and they will contact and coordinate emergency response personnel.

Fire Department (when not working on PBOW property)	(419) 627-5837
Ambulance (when not working on PBOW property)	911
Police Department (when not working on PBOW property)	(419) 627-5863
Providence Hospital (emergency)	(419) 621-7000
Firelands Regional Medical Center (non-emergency)	(419) 627-5052
National Response Center	(800) 424-8802
Poison Control Center	(800) 222-1222
Ohio EPA Emergency Spill Number	(800) 282-9378
Ohio Utilities Protection Service (Call Before You Dig)	(800) 362-2764
Linda Ingram, USACE Technical Coordinator	(615) 736-5622
Steve Downey, Shaw Project Manager	(865) 694-7496
Dave Kessler, Shaw Site Manager, Site Telephone	(419) 624-1727
William Hetrick, Shaw H&S Manager	(865) 692-3571
Dr. Jerry Berke, Health Resources, Occupational Physician	(800) 350-4511
Emergency Communications Line at PBOW	(419) 621-3222

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List of Acronyms

DNT	dinitrotoluene
H_2S	hydrogen sulfide
IT	IT Corporation
LEL	lower explosive limit
NASA	National Aeronautics and Space Administration
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PBOW	Plum Brook Ordnance Works
PPE	personal protective equipment
RAB	Restoration Advisory Board
Shaw	Shaw Environmental, Inc.
SHP	safety and health plan
SSHP	site-specific safety and health plan
USACE	U.S. Army Corps of Engineers

1.0 Site Work Plan Summary

Project Objective. The objectives of this investigation at the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio, are summarized as follows:

- Define site physical features and characteristics (aquifer background conditions).
- Evaluate fate and transport pathways (groundwater modeling).
- Define current and future routes of exposure.

Project Tasks

- Soil boring and sampling
- Monitoring well installation
- Monitoring well development
- Permeability testing
- Decontamination of equipment (high-pressure water jetting operations)
- Surveying
- Groundwater sampling.

Personnel Requirements. Up to 10 Shaw employees and subcontractors.

Note: All personnel on this site shall have received training, informational programs, and medical surveillance as outlined in the site-wide safety and health plan (SHP) (IT, 1996b [reference located in Section 7.0 of the SSAP]) for site investigations at PBOW, and be familiar with the requirements of this site-specific SHP (SSHP). Figure 1-1 presents PBOW and the hospital location map. Figure 1-2 shows the route from the PBOW facility, monitoring well installation, and soil boring drilling areas to Providence Hospital. The work zones will change daily due to the large area of the investigation. Based on the sampling, sufficient work zone boundaries will be established at least 10 feet from surface soil sampling locations and 30 feet from all well boring locations. It is anticipated a site reconnaissance will be conducted by the U.S. Army Corps of Engineers (USACE) and Shaw Environmental, Inc. (Shaw) (formerly IT Corporation [IT]) personnel prior to any activities. In addition, because this work is being conducted in public areas, local visitors and members from the Restoration Advisory Board (RAB) may also be present. Because these people are unlikely to have the necessary Occupational Safety and Health Administration (OSHA) training, special precaution must be taken to make sure all persons stay outside of the working area.

Project Schedule. Summer 2003 through Fall 2004 (well installation and 4 sampling events).

2.0 Site Characterization and Analysis

2.1 Anticipated Hazards

The activity hazard analysis in Chapter 5.0 contains project-specific practices utilized to reduce or eliminate anticipated site hazards. The activity hazard analysis indicates specific chemical and physical hazards that may be present and encountered during each task from on-site operations. Below each task is a list of hazards and specific actions that will be taken to control the respective hazards. These control measures may include work practice controls, engineering controls, and/or use of appropriate personal protective equipment (PPE).

The potential contaminants of concern include nitroaromatic compounds, semivolatile organics, and naturally occurring hydrogen sulfide (H_2S) gas in some of the deep bedrock wells. Tables 2-1 and 2-2 indicate maximum concentrations of nitroaromatic contaminants detected in soils and groundwater, respectively, during previous investigations at PBOW.

Table 2-3 contains chemicals anticipated and chemicals to be used during project activities.

2.2 General Site Information

A description of the site including location, site topography, and site accessibility is presented in Section 1.3 of the site-wide sampling and analysis plan prepared by IT in September 1996.

3.0 Personal Protective Equipment

The work activities will begin in the following levels of protection.

Task	Initial Level of PPE
Staging equipment	Level D
Soil boring and sampling	Modified Level D [1,2]
Monitoring well installation	Modified Level D[1]
Monitoring well development	Modified Level D[1]
Permeability testing	Modified Level D[1]
Decontamination of equipment	Modified Level D[1]
Surveying	Level D
Groundwater sampling	Modified Level D [1,2]

[1] Initial level will be raised to Level C or higher if air monitoring results in the worker's breathing zone are above action levels. Note: If unusual conditions or odors are encountered and air monitoring instruments do not detect volatile organic chemicals or hydrogen sulfide, turn equipment off, evacuate the work area, and contact the Health and Safety Manager for further assistance.

[2] Nitrile gloves will be worn when conducting sampling operations.

A complete description of Level D, Modified Level D, and Level C follows.

Level D. The following equipment will be used for Level D protection:

- Coveralls or work clothing
- Steel-toed safety boots
- Safety glasses
- Hearing protection (when working near/adjacent to operating equipment)
- U.S. Coast Guard-approved personal flotation device (where potential for drowning exists).

Modified Level D. The following equipment will be used for Modified Level D protection:

- Permeable Tyvek®, Kleenguard, or its equivalent
- Polyvinyl chloride boot covers
- Nitrile gloves
- Steel-toed safety boots
- Safety glasses
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Note: In addition to modified Level D PPE, the operator of high-pressure water jetting equipment shall wear metatarsal guards for foot protection, leg guards and a face shield over safety glasses.

Level C. Level C protection will not be used unless air monitoring data indicate the need for upgrade; however, the equipment shall be readily available on site. The following equipment will be used for Level C protection:

- National Institute of Occupational Safety and Health (NIOSH)-approved full face, air purifying respirators with organic vapors/acid gases/P100 cartridges (Survivair number TC-84A-0444).
- Permeable Tyvek®, taped at gloves, boots, and respirator
- Nitrile gloves (outer)
- Lightweight nitrile gloves (inner)
- Neoprene steel-toed boots or polyvinyl chloride overbooties/steel-toed safety boots
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Level B. Level protection will not be used unless air monitoring data indicate the need for upgrade will be used for Level B protection:

- Pressure-demand NIOSH-approved self-contained breathing apparatus
- Permeable Tyvek, taped at gloves, boots, and respirator (for H_2S action level)
- Nitrile gloves (outer)
- Latex or lightweight nitrile gloves (inner)
- Neoprene steel-toed boots or polyvinyl chloride overbooties/steel-toed safety boots
- Hard hat
- Hearing protection (when working near/adjacent to operating equipment).

Personnel Decontamination: All personnel working in the exclusion zone wearing modified Level D or higher must undergo personnel decontamination prior to entering the support zone. Level D will require no personnel decontamination. The personnel decontamination area shall consist of the following stations:

- ***Station 1.*** Personnel leaving the exclusion zone will remove the gross contamination from their outer clothing and boots by physical means (i.e., dislodging/displacement, rinsing, wiping, brushing etc.).

- ***Station 2.*** Equipment for this station may include plastic-lined waste receptacle, chair, clean damp cloths or paper towels, and plastic bags. At Station 2, personnel will remove their Tyvek coveralls and gloves and deposit them in the lined waste receptacles. Personnel will wipe their respirators (if used), hard hats, and boots with clean, damp cloths and then remove those items. Those items are then hand-carried to the next station.

- ***Station 3.*** Equipment for this station may include a wash basin with soap and water and a respirator sanitation station. At this station, personnel will thoroughly wash their hands and face before leaving the decontamination zone. Respirators will be sanitized and then placed in a clean, plastic ziplock® bag. Disposable personnel protective equipment that is generated will be double-bagged and disposed of in on-site dumpsters.

Donning Procedures

- Put on chemical-resistant boots or boots with boot covers and tape the coveralls over the boots at the ankles.

- Put on gloves.

- Tape the coveralls over the gloves at the wrist.

- If Level C PPE is required, don respirator and check for secure fit.

- Put hood or head covering over the respirator.

- Put on the remaining protective equipment (i.e., hard hat, safety glasses, etc.).

4.0 Site Monitoring

The environmental contaminants of concern are volatile and semivolatile compounds including 2,4-dinitrotoluene (DNT); 2,6-DNT; 1,3,5-trinitrobenzene; 2,4,6-trinitrotoluene and naturally occurring H_2S gas detected in some of the deep bedrock wells.

Table 4-1 contains action levels for site monitoring.

Monitoring will be performed by the site safety and health officer initially for the location, then periodically during the performance of boring operations (sampling every 5- to 10-foot soil boring depth). A calibrated photoionization detector with a lamp power of at least 10.6 or 11.7 electrovolts will be utilized to monitor the wells and breathing zones to determine if any organic vapors may be present that would necessitate upgrading of protection level. A calibrated multi-gas meter capable of measuring lower explosive limit (LEL), oxygen, and hydrogen sulfide will be utilized to monitor the work sites and breathing zones for explosive, flammable, and toxic vapors. Benzene detector tubes will be utilized, as needed, to monitor breathing zones for benzene. Table 4-2 describes the air monitoring frequency and location.

No air monitoring is required for operations that do not disturb existing materials (i.e., site setup, surveying, decontamination, and miscellaneous support zone activities).

5.0 Activity Hazard Analysis

The attached activity hazard analysis (Table 5-1) is provided for the following activities:

- Setup of equipment and general field activities
- Soil boring and sampling
- Monitoring well installation
- Monitoring well development
- Groundwater sampling
- Decontamination (high-pressure water jetting operations)
- Surveying.

Because of high levels of hydrogen sulfide have been encountered during previous monitoring sampling events, a process flow diagram to be used during bedrock well sampling has been included as Figure 5-1.

TABLES

Table 2-1

Maximum Concentrations of Nitroaromatic Compounds in Soil Samples Collected Previously Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Maximum Soil Concentration, **Background** (mg/kg)	Maximum Soil Concentration, **Downgradient** (mg/kg)
2,4,6-Trinitrotoluene	Not Analyzed	Not Analyzed
1,3,5-Trinitrobenzene	Not Analyzed	Not Analyzed
1,3-Dinitrobenzene	Not Analyzed	Not Analyzed
Nitrobenzene	Not Analyzed	Not Analyzed
2,4-Dinitrotoluene	Not Analyzed	Not Analyzed
2,6-Dinitrotoluene	Not Analyzed	Not Analyzed
3,4-Dinitrotoluene	Not Analyzed	Not Analyzed
2-Amino-4-Nitrotoluene	Not Analyzed	Not Analyzed
4-Amino-2-Nitrotoluene	Not Analyzed	Not Analyzed
2-Amino-4,6-Dinitrotoluene	Not Analyzed	Not Analyzed
4-Amino-2,6-Dinitrotoluene	Not Analyzed	Not Analyzed

mg/kg – milligrams per kilogram.

Table 2-2

Maximum Concentrations of Nitroaromatic Compounds in Groundwater Samples Collected Previously Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Maximum **Overburden/Shale** Groundwater Concentration **Background Wells** (µg/L)	Maximum **Bedrock** Groundwater Concentration **Background Wells** (µg/L)
2,4,6-Trinitrotoluene	Not Detected	Not Detected
1,3,5-Trinitrobenzene	Not Detected	Not Detected
1,3-Dinitrobenzene	Not Detected	Not Detected
Nitrobenzene	Not Detected	0.33
2,4-Dinitrotoluene	Not Detected	Not Detected
2,6-Dinitrotoluene	Not Detected	0.43
3-Nitrotoluene	Not Detected	Not Detected
2-Amino-4,6-Dinitrotoluene	Not Detected	Not Detected
4-Amino-2,6-Dinitrotoluene	Not Detected	Not Detected
RDX	Not Detected	0.22J

Chemical	Maximum **Overburden/Shale** Groundwater Concentration **Downgradient Wells** (µg/L)	Maximum **Bedrock** Groundwater Concentration **Downgradient Wells** (µg/L)
2,4,6-Trinitrotoluene	Not Detected	0.27
1,3,5-Trinitrobenzene	Not Detected	Not Detected
1,3-Dinitrobenzene	0.21 BU	0.22
Nitrobenzene	Not Detected	0.34
2,4-Dinitrotoluene	0.1	1.5
2,6-Dinitrotoluene	0.44	1.1
2-Nitrotoluene	0.59 UJ	0.55
3-Nitrotoluene	13	0.62
Tetryl	0.41	Not Detected
2-Amino-4,6-Dinitrotoluene	Not Detected	Not Detected
4-Amino-2,6-Dinitrotoluene	Not Detected	Not Detected
RDX	Not Detected	0.17 J

Background overburden/shale wells include: IT-MW01.
Background bedrock wells include: BG8-BEDGW-001, BED-MW20, BED-MW24, BED-MW25.
Downgradient overburden/shale wells include: MK-MW09, MK-MW11, IT-MW06, MK-MW23.
Downgradient bedrock wells include: BED-MW17, BED-MW19, BED-MW22, BED-MW27.
RDX – Research Development Explosive.
µg/L – micrograms per liter.

Table 2-3

Toxicological and Physical Properties of Chemicals
Former Plum Brook Ordnance Works
Sandusky, Ohio

Substance [CAS]	IP[a] (eV)	Odor Threshold (ppm)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
1,3-Dinitrobenzene [99-65-0]	10.43	?	Inh Abs Ing Con	Anoxia, cyanosis, visual disturbances, central blind spot of vision, bad taste, burning of mouth, dry throat, thirsty; yellowing hair, eyes, and skin; anemia, liver damage.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention	1 mg/m³ (skin) 0.15 ppm (skin) 1 mg/m³ (skin)	-	PEL TLV REL	50 mg/m³
Benzene [71-43-2]	9.24	34-119	Inh Abs Ing Con	Irritates eyes, nose, respiratory system; giddiness; headache, nausea, staggered gait; fatigue, anorexia, lassitude; dermatitis; bone-marrow depression. Carcinogenic.	Eye: Irrigate immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	1 ppm (0.5 ppm) 0.1 ppm	5 ppm 2.5 ppm C1 ppm (Ca)	PEL TLV REL	Ca [500 ppm]* *OSHA
Chromium (as Cr) [7440-47-3]	NA	NA	Inh Ing Con	Irritation of eyes, skin, and upper respiratory system; fibrosis of lungs.	Eye: Irrigate immediately Skin: Wash flush Breath: Respiratory support Swallow: Immediate medical attention	1 mg/m³ 0.5 mg/m³ 0,5 mg/m³	- -	PEL TLV REL	250mg/m³ (as Cr)
Dinitrotoluene (DNT)	NA	?	Inh Abs Ing Con	Anoxia, cyanosis, anemia, jaundice; reproductive effects. Animal carcinogen.	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention	1.5 mg/³ (skin) 0.2 mg/m³ (skin) 1.5 mg/m³ (skin)	- - -	PEL TLV REL	Ca [50 mg/m³)
Ethyl benzene [100-41-4]	8.76	0.09-0.6	Inh Ing Con	Irritates eyes, mucous membranes; headache; dermatitis; narcosis, coma.	Eye: Irrigate immediately Skin: Water flush promptly Breath: Respiratory support Swallow: Immediate medical attention	100 ppm 100 ppm 100 ppm	125 ppm 125 ppm	PEL TLV REL	800 ppm

Table 2-3

Toxicological and Physical Properties of Chemicals
Former Plum Brook Ordnance Works
Sandusky, Ohio

Substance [CAS]	IP[a] (eV)	Odor Threshold (ppm)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
Gasoline [8006-61-9]	?	0.3	Inh Ing Con	Intoxication, headaches, blurred vision, dizziness, nausea; eye, nose, and throat irritation; potential kidney and other cancers. Carcinogenic.	Eye: Irrigate immediately (15 min) Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	None 300 ppm Ca, lowest feasible conc. (LOQ 15 ppm)	None 500 ppm	PEL TLV REL	1,400 ppm
Hydrogen Sulfide [7783-06-4]	10.46	0.001- 0.13	Inh Con	Cough, dizziness, headache. Labored breathing, nausea, Unconsciousness. On contact with liquid: Frostbite	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support	10 ppm	50 ppm (10 min) C 20 ppm 15 ppm C 10 ppm (10 min)	PEL TLV REL	100 ppm
Methanol	10.85	4.2-5960	Inh Abs Ing Con	Irritated eyes, headache, drowsiness, lightheadedness, nausea, vomiting, disturbance in vision, blindness.	Eye: Irrigate immediately Skin: Water flush promptly Breath: Fresh air Swallow: Immediate medical attention	200 ppm (skin) 200 ppm (skin) 200 ppm (skin)	250 ppm (skin) 250 ppm (skin)	PEL TLV REL	6,000 ppm
Nitric acid [7697-37-2]	11.95	0.3-1	Inh Ing Con	Irritated eyes, mucous membranes, and skin; delayed pulmonary edema, pneumonitis, bronchitis; dental erosion.	Eye: Irrigate immediately Skin: Wash flush promptly Breath: Respiratory support Swallow: Immediate medical attention	2 ppm 2 ppm 2 ppm	4 ppm 4 ppm	PEL TLV REL	25 ppm
Nitrobenzene [98-95-3]	9.92	0.37	Inh Abs Ing Con	Irritation of eyes, skin, anoxia; dermatitis; anemia; methemoglobinemia; testicular effects.	Eye: Irrigate immediately Skin: Wash flush Breath: Respiratory support Swallow: Immediate medical attention	1 ppm (skin) 1 ppm (skin) 1 ppm (skin)	-	PEL TLV REL	200 ppm
Portland cement	NA	NA	Inh	Fine gray powder that can be irritating if inhaled or in eyes.	Eye: Irrigate immediately Skin: Soap wash flush Breath: Respiratory support Swallow: Immediate medical attention	10 mg/m^3 15 mg/m^3 total dust 5 mg/m^3 respirable fr. 10 mg/m^3/total dust 5 mg/m^3 respirable	-	TLV PEL	

Table 2-3

Toxicological and Physical Properties of Chemicals
Former Plum Brook Ordnance Works
Sandusky, Ohio

Substance [CAS]	IP[a] (eV)	Odor Threshold (ppm)	Route[b]	Symptoms of Exposure	Treatment	TWA[c]	STEL[d]	Source[e]	IDLH (NIOSH)[f]
						fraction		REL	
Toluene [108-88-3]	8.82	0.16-37	Inh Abs Ing Con	Fatigue, weakness; confusion, euphoria, dizziness, headache; dilated pupils, lacrimation; nervousness, muscular fatigue, insomnia; paralysis; dermatitis.	Eye: Irrigate immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	200 ppm 50 ppm (skin) 100 ppm	300 ppm (c) 150 ppm	PEL TLV REL	500 ppm
1,3,5-Trinitrobenzene [Exposure data provided for nitrobenzene; no exposure data available for 1,3,5-trinitrobenzene)	?	?	Inh Ing Con Abs	Irritating to the skin, mucus membranes, and eyes; nausea, vomiting, diarrhea, and abdominal pain; liver damage.	Eye: Irrigate immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	1 ppm (skin) 1 ppm (skin) 1 ppm (skin)	-	PEL TLV REL	1800 ppm
Trinitrotoluene (TNT) [118-96-7]	10.59	?	Inh Abs Ing Con	Irritation of skin, mucous membranes; liver damage, jaundice; cyanosis, sore throat; kidney damage; cardio irregularity.	Eye: Irrigate immediately Skin: Soap wash promptly Breath: Respiratory support Swallow: Immediate medical attention	1.5 mg/m^3 (skin) 0.1 mg/m^3 (skin) 0.5 mg/m^3 (skin)	-	PEL TLV REL	500 mg/m^3

[a]IP = Ionization potential (electron volts [eV]).
[b]Route = Inh, Inhalation; Abs, Skin absorption; Ing, Ingestion; Con, Skin and/or eye contact.
[c]TWA = Time-weighted average. The TWA concentration for a normal work day (usually 8 or 10 hours) and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day without adverse effect.
[d]STEL = Short-term exposure limit. A 15-minute TWA exposure that should not be exceeded at any time during a work day, even if the TWA is not exceeded.
[e]PEL = Occupational Safety and Health Administration (OSHA) permissible exposure limit (29 CFR 1910.1000, Table Z).
TLV = American Conference of Governmental Industrial Hygiene (ACGIH) threshold limit value—TWA.
REL = National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit.
[f]IDLH (NIOSH)—Immediately dangerous to life or health (NIOSH). Represents the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects.
NE = No evidence could be found for the existence of an IDLH (NIOSH Pocket Guide to Chemical Hazards, Pub. No. 90-117, 1990).
? = Unknown.
C = Ceiling limit value which should not be exceeded at any time.

Table 2-3

Toxicological and Physical Properties of Chemicals
Former Plum Brook Ordnance Works
Sandusky, Ohio

Ca = Carcinogen.
NA = Not applicable.
NIC = Notice of intended change (ACGIH).
DNT – Dinitrotoluene.
Cr – Chromium.
mg/m^3 – Milligram(s) per cubic meter.
ppm – Parts per million.
min – minute.
Fr. – Fraction.
LOQ – Limit of quantification.
Conc – Concentration.
TNT – Trinitrotoluene.

Table 4-1

Action Levels
Former Plum Brook Ordnance Works
Sandusky, Ohio

When in Level B PPE

Analyte	Action Level[a]	Required Action[b]
VOCs	≥ 50 ppm above background	Stop work; evacuate work area; contact H&S Manager
Benzene	≥ 10 ppm in BZ	Stop work; evacuate work area; contact H&S Manager
Dust	≥ 5 mg/cu. meter	Stop work; initiate dust suppression
LEL	≥ 10% of LEL	Stop work; evacuate work area; contact H&S Manager
O_2	> 23 % < 19.5%	Stop work; evacuate work area; contact H&S Manager
H_2S	100 ppm (IDLH) in BZ	Stop work; evacuate work area; contact H&S Manager

When in Level C PPE

Analyte	Action Level[a]	Required Action[b]
VOCs	≥ 25 ppm above background	Stop work; evacuate work area; upgrade to Level B
Benzene	≥ 5 ppm in BZ	Stop work; evacuate work area; upgrade to Level B
Dust	≥ 5 mg/cu. meter	Stop work; initiate dust suppression
LEL	≥ 10% of LEL	Stop work; evacuate work area; contact H&S Manager
O_2	> 23 % < 19.5%	Stop work; evacuate work area; contact H&S Manager

Table 4-1

Action Levels
Former Plum Brook Ordnance Works
Sandusky, Ohio

When in Modified Level D PPE/Level D PPE

Analyte	Action Level[a]	Required Action[b]
VOCs	≥ 5 ppm above background	Stop work; evacuate work area; upgrade to Level C PPE
Benzene	≥ 1 ppm in BZ	Stop work; evacuate work area; upgrade to Level C PPE
Dust	≥ 0.5 mg/cu. meter	Stop work; initiate dust suppression
LEL	≥ 10% of LEL	Stop work; evacuate work area; contact H&S Manager
O_2	> 23 % < 19.5%	Stop work; evacuate work area; contact H&S Manager
H_2S	> 5 ppm in BZ	[c] Stop work; evacuate work area; contact H&S Manager, upgrade to Level B PPE or activate a ventilation system to keep H_2S vapors below >5 ppm in BZ

When in Support Zone

Analyte	Action Level	Required Action
Dust	≥ 0. 5 mg/cu. meter	Stop work; initiate dust suppression
VOCs	≥ 1 ppm above background	Stop work; evacuate work area; contact H&S Manager

BZ = Breathing zone.
LEL = Lower explosive limit.
VOCs = Volatile organic compounds.
ppm = parts per million
H&S = health and safety
mg/cu. meter = milligrams per cubic meter
PPE =Personal protective equipment.
H_2S = Hydrogen sulfide.
IDLH = Immediate danger to life or health.
O_2 = Oxygen.

[a] Four instantaneous peaks in any 15-minute period or a sustained reading for 5 minutes in excess of the action level will trigger a response.
[b] Contact with the Shaw H&S manager, USACE and Shaw project manager must be made prior to continuance of work. The H&S manager may then initiate perimeter/integrated air sampling along with additional engineering controls.
[c] If H_2S vapors exceed 5 ppm in BZ, proceed to Level B (no respirator cartridges are able to remove hydrogen sulfide).

Table 4-2

Air Monitoring Frequency and Location
Former Plum Brook Ordnance Works
Sandusky, Ohio

Work Activity	Instrument	Frequency	Location
Soil boring and sampling	OV Monitor Tri-Gas Meter BDT, as needed	Continuously Continuously	BZ of employees and/or work area
Monitoring well installation	OV Monitor Tri-Gas Meter BDT, as needed	Continuously Continuously	BZ of employees and/or work area
Groundwater sampling	OV Monitor Tri-Gas Meter BDT, as needed	Continuously Continuously	BZ of employees and/or work area

OV = Organic vapor.
Tri-Gas Meter = Combustible gas, oxygen and hydrogen sulfide monitor.
BDT = Benzene detector tube.
BZ = Breathing zone.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities	Slip, trip, and fall hazards	• Determine best access route before transporting equipment. • Practice good housekeeping; keep work area picked up and clean as feasible. • Continually inspect the work area for slip, trip, and fall hazards. • Look before you step; ensure safe and secure footing.
	Heavy lifting	• Use proper lifting techniques. Lifts greater than 60 pounds require assistance or mechanical equipment.
	Falling objects	• Stay alert and clear of materials suspended overhead; wear hard hat and steel-toed boots.
	Flying debris, dirt, dust, etc.	• Wear safety glasses/goggles; ensure that eye wash is in proper working condition.
	Pinch points	• Keep hands, fingers, and feet clear of moving/suspended materials and equipment. • Beware of contact points. • Stay alert at all times!
	Cuts/bruises	• Use cotton or leather work gloves for material handling.
	Bees, spiders, and snakes	• Inspect work area carefully and avoid placing hands and feet into concealed areas.
	Fire	• Fire extinguishers shall be suitably placed, distinctly marked, readily accessible, and maintained in a fully charged and operable condition.
	Hazard communication	• Label all containers as to contents and dispose of properly. • Ensure Material Safety Data Sheets (MSDS) are available for hazardous chemicals used on site.
	Noise	• Sound levels above 85 A-weighted decibels (dBA) mandates hearing protection.
	Lighting	• Adequate lighting will be provided to ensure a safe working environment.
	Cold stress	• Workers should wear insulated clothing when temperatures drop below 40°F. • Drink warm beverages on breaks. Refrain from drinking caffeinated beverages. • Remove wet clothing promptly. • Take breaks in warm areas. • Reduce work periods as necessary. • Layer work clothing.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities (continued)	Frostbite	• Personnel should wear inner cotton gloves and insulating socks to protect extremities from cold weather. • Take breaks in warm areas. • Remove wet gloves and socks promptly.
	Poison ivy/oak/sumac	• Avoid plant areas if possible. • Wear long sleeves and long pants. • Promptly wash clothing that has contacted poisonous plants. • Wash affected areas immediately with soap and water.
	Ticks	• Wear light-colored clothing (can see ticks better). • Mow vegetated and small brush areas. • Wear insect repellant. • Wear long sleeves and long pants. • Visually check oneself promptly and frequently after exiting the work area.
	Heat rash	• Keep the skin clean and dry. • Change perspiration-soaked clothing, as necessary. • Bathe at end of work shift or day. • Apply powder to affected area.
	Heat cramps	• Drink plenty of cool fluids even when not thirsty. • Provide cool fluid for work crews. • Move victim to shaded, cool area.
	Heat exhaustion	• Conduct physiological worker monitoring as needed (i.e., heart rate, oral temperature). • Set up work/rest periods. • Use the buddy system. • Allow workers time to acclimate. • Have ice packs available for use. • Take frequent breaks.
	Heat stroke	• Evaluate possibility of night work. • Perform physiological monitoring on workers during breaks. • Wear body cooling devices.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities (continued)	Contact with moving equipment/vehicles	• Work area will be barricaded/demarcated. • Equipment will be laid out in an area free of traffic flow. • Barricades shall be used on or around work areas when it is necessary to prevent the inadvertent intrusion of pedestrian traffic. • Barriers shall be used to protect workers from vehicular traffic. • Barriers shall be used to guard excavations adjacent to streets or roadways. • Flagging shall be used for the short term (less than 24 hours) to identify hazards until proper barricades or barriers are provided. • Heavy equipment shall have backup alarms.
	Forklift operations	• Use qualified and trained forklift operators. • The operator shall not exceed the load capacity rating for the forklift. • The load capacity shall be clearly visible on the forklift. • Forklift operators shall inform their supervisor of any prescribed medication that they are taking that would impair their judgement.
	Portable electric tools	• Portable electric tools which are unsafe due to faulty plugs, damaged cords, or other reason, shall be tagged (do not use) and be removed from service. • Portable electric tools and all cord and plug connected equipment shall be protected by a ground-fault circuit interrupter (GFCI) device. • Electrical tools shall be inspected daily prior to use.
	Extension cords	• Extension cords that have faulty plugs, damaged insulation, or are unsafe in any way shall be removed from service. • Cords shall be protected from damage from sharp edges, projections, pinch points (doorways), and vehicular traffic. • Cords shall be suspended with a nonconductive support (rope, plastic ties, etc.). • Cords shall be designed for hard duty. • Cords shall be inspected daily.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Setup of equipment and general field activities (continued)	Lightning strikes	• Whenever possible, halt activities and take cover. • If outdoors, stay low to the ground. • Limit the body surface area that is in contact with the ground (i.e., kneeling on one knee is better than laying on the ground). • Seek shelter in a building if possible. • Stay away from windows. • If available, crouch under a group of trees instead of one single tree. • Keep all body parts in contact with the ground as close as possible. • Remain 6 feet away from tree trunk if seeking shelter beneath tree(s). • If in a group, keep 6 feet of distance between people.
	Thunderstorms, tornadoes	• Listen to radio or TV announcements for pending weather information. • Cease field activities during thunderstorm or tornado warnings. • Seek shelter. Do not try to outrun a tornado.
	Travel on-site/off-site, between soil borings and monitoring well locations	• Obey the speed limit. • Drive with care paying particular attention to animals crossing the road. Deer are numerous on site and may attempt to cross or jump onto the road.
Surveying	Slip, trip, fall	• Site workers will be required to wear safety glasses with side shields, work gloves, and steel-toe boots when working in the field. • Provide adequate lighting in all work areas. • Whenever possible, avoid routing cords and hoses across walking pathways. • Flag or cover inconspicuous holes to protect against falls. • Work areas will be kept clean and orderly. • Garbage and trash will be disposed of daily in approved refuse containers. • Tools and accessories will be properly maintained and stored. • Work areas and floors will be kept free of dirt, grease, and slippery materials.
	Traffic accidents	• Place physical barrier (i.e., barricades, fencing) around work areas regularly occupied by pedestrians. • If working adjacent to roadways, have workers wear fluorescent orange vests. • Use warning signs or lights to alert oncoming traffic. • Assign flag person(s) if necessary to direct local traffic. • Set up temporary parking locations outside the immediate work area. • Motor vehicle operators shall obey all posted traffic signs, signals, and speed limits. • Pedestrians have the right-of-way. • Wear seat belts when vehicles are in motion.
	Wildlife hazards	• Workers should be cautious when driving through the site in order to avoid encounters with passing animals, particularly deer.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Soil Boring and Sampling	Overhead hazards	• Make sure no obstacles are within radius of boom. Always stay a safe distance from power lines.
	Faulty or damaged equipment being utilized to perform work	• All machinery or mechanized equipment will be inspected by a competent mechanic and be certified to be in safe operating condition. • Equipment will be inspected before being put to use and at the beginning of each shift. • Faulty/unsafe equipment will be tagged and if possible locked out. • Drill rigs shall be equipped with reverse signal alarm, backup warning lights, or the vehicle is backed up only when an observer signals it is safe to do so.
	Uneven terrain, poor ground support, inadequate clearances, contact with utilities	• Inspections or determinations of road conditions and structures shall be made in advance to ensure that clearances and load capacities are safe for the passage or placing of any machinery or equipment. • All mobile equipment and areas in which they are operated shall be adequately illuminated. • Aboveground and belowground utilities will be verified with National Aeronautics and Space Administration (NASA) personnel, and delineated or flagged prior to staging equipment. • Whenever the equipment is parked, the parking brake shall be set. • Equipment parked on inclines will have the wheels chocked. • Inspect brakes and tire pressure on drill rig before staging for work.
	Inexperienced operator	• Machinery and mechanized equipment shall be operated only by designated personnel. • Operators shall inform their supervisor(s) of any prescribed medication that they are taking that would impair their judgment.
	Jacks/outriggers	• Ensure proper footing and cribbing.
	Falling objects	• Remove unsecured tools and materials before raising or lowering the derrick. • Stay alert and clear of materials suspended overhead.
	Pinch points	• Keep feet and hands clear of moving/suspended materials and equipment. • Stay alert at all times!
	Fire	• Mechanized equipment shall be shut down prior to and during fueling operations. • Have fire extinguishers inspected and readily available.
	Fall hazards	• Personnel are not allowed to work off of machinery or use machinery as ladders. • Use fall protection when working above 6 feet.
	Noise	• Hearing protection is mandatory above 85 dBA.
	Contact with rotating or reciprocating machine parts	• Use machine guards; use long-handled shovels to remove auger cuttings. • Use safe lockout procedures for maintenance work.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Soil Boring and Sampling (continued)	Heavy lifting	• Use proper lifting techniques. Lifts greater than 60 pounds require assistance or mechanical equipment; size-up the lift.
	Slip, trip, and fall hazards	• Practice good housekeeping; keep work area picked up and clean as feasible. • Continually inspect the work area for slip, trip, and fall hazards.
	Contact with potentially contaminated materials	• Real-time air monitoring will take place. If necessary, proper personal protective clothing and equipment will be utilized. • Stop immediately at any sign of obstruction. • Do not breathe air surrounding boring unless necessary. • Upgrade to respirator if necessary. • Avoid skin contact with soil cuttings. Wear gloves. • Stay clear of moving parts of drill rig.
	Drum handling	• Be careful not to breathe air from around open drum any more than necessary. Monitor with photoionization detector/flame ionization detector (PID/FID) equipment and upgrade to respirator if necessary. • When filling a drum (with either soil or water), be careful not to make contact with the contained waste. Wear appropriate gloves. Make sure lid or bung of drum is secure. • If moving a drum unassisted, be sure to leverage properly, use proper lifting techniques, and wear safety glasses and steel-toed boots. • When using a drum dolly, make sure straps and lid catch are securely attached. Leverage properly when tilting drum. Be sure toes stay away from drum.
High-Pressure Water Cleaning Operations	Heavy lifting	• Use proper lifting techniques. • Lifts greater than 60 pounds require assistance or mechanical equipment • Size-up the lift.
	Slip, trip, and fall hazards	• Good housekeeping shall be implemented. • The work area shall be kept clean as feasible. • Inspect the work area for slip, trip, and fall hazards.
	Fueling	• Only approved safety cans shall be used to store fuel. • Do not refuel equipment while it is operating or still hot to the touch. • Fire extinguishers shall be suitably placed, distinctly marked, readily accessible, and maintained in a fully charged and operable condition.
	Faulty or damaged equipment	• Equipment shall be inspected before being placed into service and at the beginning of each shift. • Preventive maintenance procedures recommended by the manufacturer shall be followed. • A lockout/tagout procedure shall be used for equipment found to be faulty or undergoing maintenance.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
High-Pressure Water Cleaning Operations (continued)	High-pressure water	• Jetting gun operator must wear appropriate PPE including hard hat, impact-resistant safety glasses with side shields, water-resistant clothing, metatarsal guards for feet and legs, and hearing protection (if appropriate). • One standby person shall be available within the vicinity of the pump during jetting operation. • The work area shall be isolated and adequate barriers will be used to warn other site personnel.
	Unqualified operators	• Only qualified and trained personnel are permitted to operate machinery and mechanized equipment associated with water jet cutting and cleaning.
	Out of control equipment	• No machinery or equipment is permitted to run unattended. • Machinery or equipment will not be operated in a manner that will endanger persons or property nor will the safe operating speeds or loads be exceeded.
	Noise	• Sound levels above 85 dBA mandates hearing protection by nearby site personnel.
	Activation during repairs	• All machinery or equipment will be shut down and positive means taken to prevent its operation while repairs or manual lubrications are being done.
	Pinch points	• Keep feet and hands clear of moving/suspended materials and equipment. • Stay alert and clear of materials suspended
	Falling objects	• Hard hats are required by site personnel. • Stay alert and clear of material suspended overhead.
	Flying debris	• Impact-resistant safety glasses with side shields are required.
	Contact with potentially contaminated materials	• All site personnel will wear the appropriate personal protective equipment (PPE).
Drilling, Well Development, and Groundwater Well Sampling	Heavy lifting	• Use proper lifting techniques. • Lifts greater than 60 pounds require assistance or mechanical equipment. • Size-up the lift. • Get assistance when necessary. • If a worker loses control of an item, STAND CLEAR and DO NOT try to prevent its fall.

Table 5-1

Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Drilling, Well Development, and Groundwater Well Sampling (continued)	Cross-contamination and contact with potentially contaminated materials	• Sampling technicians will wear proper protective clothing and equipment to safeguard against potential contamination. • Avoid skin contact with water. • Handle samples with care. • Only essential personnel will be in the work area. • Real-time air monitoring will take place before and during sampling activities. • All personnel will follow good hygiene practices. • Proper decontamination procedures will be followed. • All liquids and materials used for decontamination will be contained and disposed of in accordance with federal, state, and local regulations.
	Heat rash	• Keep the skin clean and dry. • Change perspiration-soaked clothing, as necessary. • Bathe at end of work shift or day. • Apply powder to affected area.
	Heat cramps	• Drink plenty of cool fluids even when not thirsty. • Provide cool fluid for work crews. • Move victim to shaded, cool area.
	Heat exhaustion	• Conduct physiological worker monitoring as needed (i.e., heart rate, oral temperature). • Set up work/rest periods. • Use the "buddy system." • Allow workers time to acclimate. • Have ice packs available for use. • Take frequent breaks.
	Heat stroke	• Evaluate possibility of night work. • Perform physiological monitoring on workers during breaks. • Wear body cooling devices.
	Flammable Vapor	• Real-time O_2/LEL/H_2S air monitoring shall be performed at the monitoring well top-of-casing after opening and during the purge and sampling activities. • Sampling and support equipment shall be positioned up wind of the monitoring well whenever possible. • Suspend activities if > 10% lower explosive limit (LEL) is measured in the breathing zone, stop all potential ignition sources.
	Hydrogen Sulfide (H_2S)	• Real-time O_2/LEL/H_2S air monitoring shall be performed at the monitoring well top-of-casing after opening and during the purge and sampling activities. • Contact the Health and Safety Manager when > 5 ppm H_2S is measured in the breathing zone (Reference Table 4-1 Action Levels). • Establish engineering controls to reduce H_2S concentrations in the breathing zone, this could include induced ventilation or mechanical movement of vapor from the well head using appropriate explosion proof blowers and equipment. • Upgrade to Level B PPE if H_2S measurements are sustained in the breathing zone in excess of the action limits.

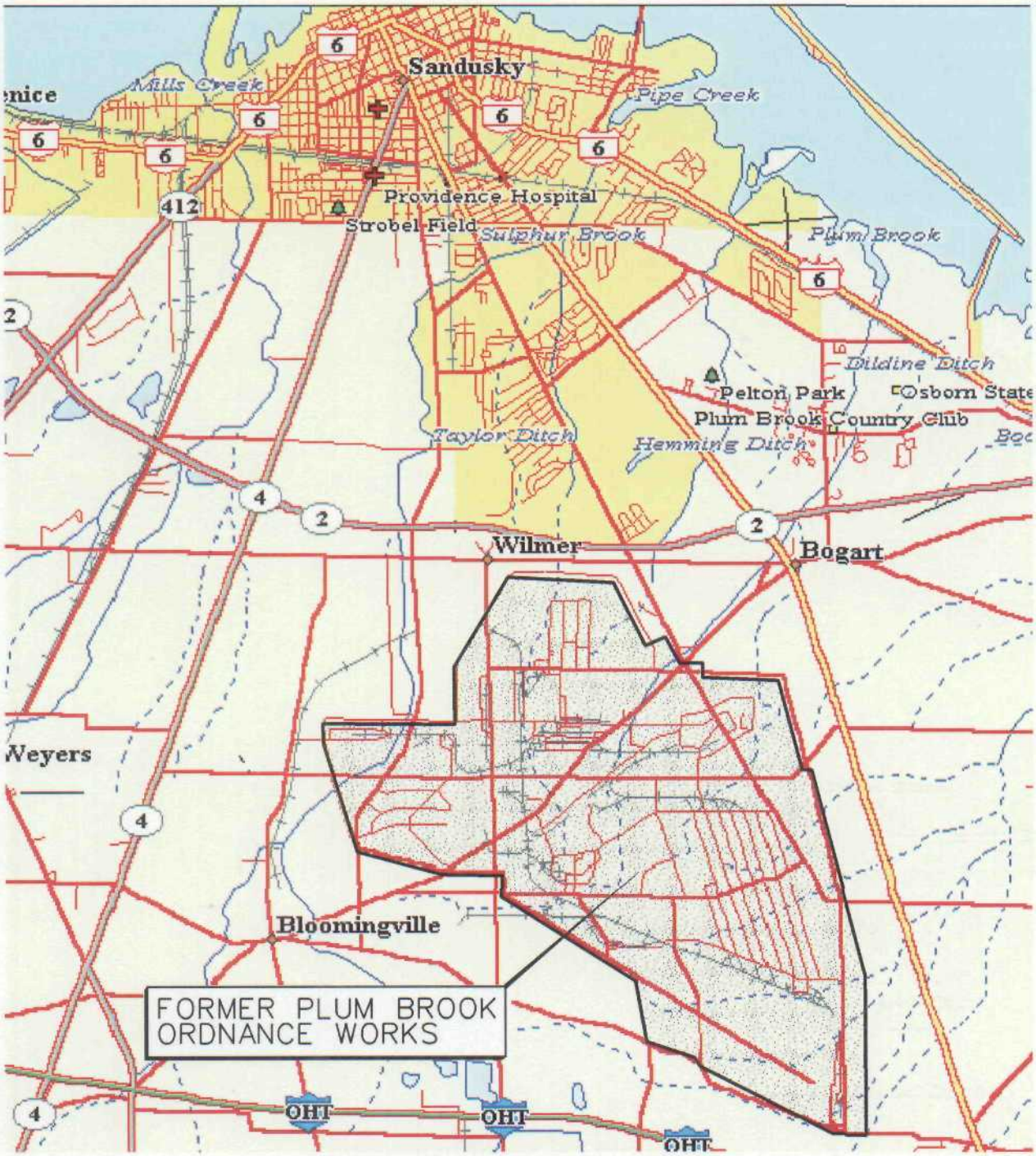
Table 5-1

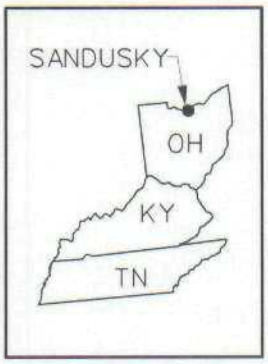
Activity Hazard Analysis
Former Plum Brook Ordnance Works
Sandusky, Ohio

Activity	Potential Hazards	Recommended Controls
Drilling, Well Development, and Groundwater Well Sampling (continued)	Traffic Accident Prevention/Control	• Place physical barrier (i.e., barricades, fencing) around work areas regularly occupied by pedestrians. • If working adjacent to roadways, have workers were fluorescent orange vests. • Use warning sings of lights to alert oncoming traffic. • Assign flag person(s) if necessary to direct local traffic. • Set up temporary parking locations outside the immediate work area. • Motor vehicle operations shall obey all posted traffic signs, signals, and speed limits. • Pedestrians have the right-of-way. • Wear seat belts when vehicles are in motion.
	Chemical Exposure to Petroleum Hydrocarbons	• Use PPE and respiratory protection as specified. • Conduct air monitoring prior to and during intrusive activities. • Use the buddy system. • Do not work in areas without PPE where concentrations exceed action levels. • Material Safety Data Sheets (MSDS) shall be obtained for chemicals brought on site. • MSDSs shall be reviewed wit project personnel before using the chemical material.
	Underground Hazards	• Before beginning intrusive activities, the field supervisor shall ensure that underground utilities are located. • Look at underground drawings if available. • When underground utilities are exposed, they shall be protected to avoid damage. • Personnel on the ground will assist in probing the soils to find the exact location of the lines and will use hand shovels to carefully remove the soil adjacent to the lines. • Identify the work area to b cleared.
	Noise	• Review elements of Hearing Conservation Program. • Require use of hearing protection when noise levels are at or exceed 85 dBA. • Exposure to impulsive or impact noise should not exceed 140 dBA peak sound level. • Use engineering controls (i.e., guards, mufflers, distance) to reduce workers exposure. • Conduct noise surveys on activities in question. • Inform employees of high noise areas where hearing protection is required and demarcate these areas.
	Pinch Points	• Keep hands and feet clear of moving/suspended/rotating equipment. • Wear hard-toe/shank safety boots.
	Cuts/Bruises	• Use cotton or leather work gloves for material handling.

MSDS – Material Safety Data Sheet.
dBA – A-weighted decibel.
°F – Degrees Fahreinheit.
GFCI – Ground-fault circuit interrupter.
NASA – National Aeronautics and Space Administration.
PID – Photoionization detector.
ppm –parts per million
FID – Flame ionization detector.
PPE – Personal protective equipment.
O_2 – Oxygen.
LEL - Lower explosive limit.
H_2S – Hydrogen sulfide.

FIGURES





NOT TO SCALE

FIGURE 1-1
VICINITY MAP

FORMER PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

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PROJ. NO.: 843656
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWNEY
INITIATOR: N.SIREK
CADD REVIEW: C.BENTLEY
STARTING DATE: 08MAY03
DRAWN BY: C.TUMLIN
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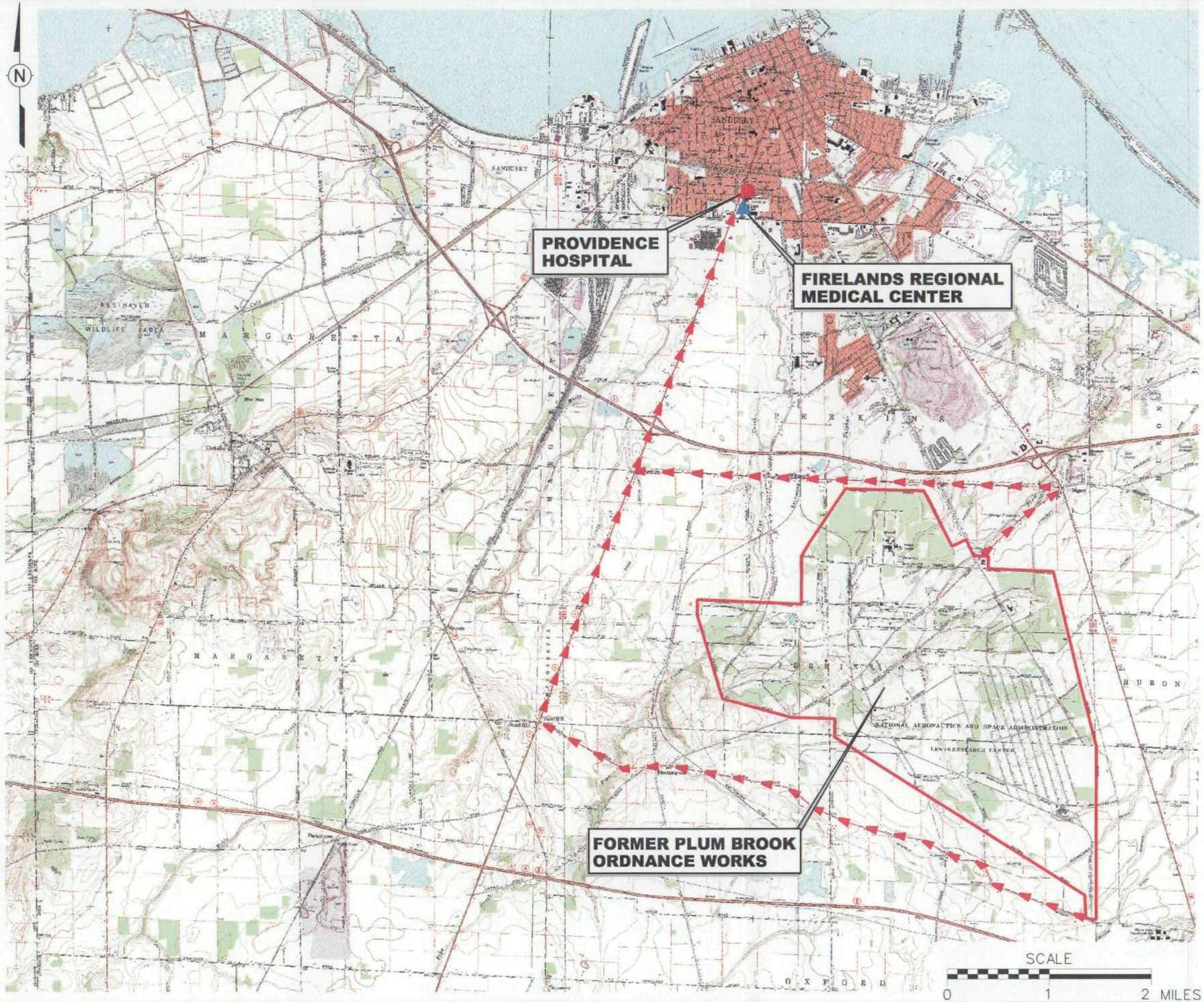

LEGEND

(EMERGENCY)
PROVIDENCE HOSPITAL
1912 HAYES AVENUE
SANDUSKY, OHIO 44870
Phone: (419) 621-7000 or 911

(NON-EMERGENCY)
FIRELANDS REGIONAL MEDICAL CENTER
2020 HAYES AVENUE
SANDUSKY, OHIO 44870
Phone: (419) 627-5052
Contact: SANDIE McBRIDE

DESTINATION ROUTES

FIGURE 1-2
HOSPITAL LOCATION MAP WITH DESTINATION ROUTES

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental, Inc.

DWG. NO.: 843656-pbow-ssap-0008.dgn
PROJ. NO.: 843656
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWNEY
INITIATOR: D.KESSLER
CADD REVIEW: C.BENTLEY
STARTING DATE: 12MAY03
DRAWN BY: C.TUMLIN
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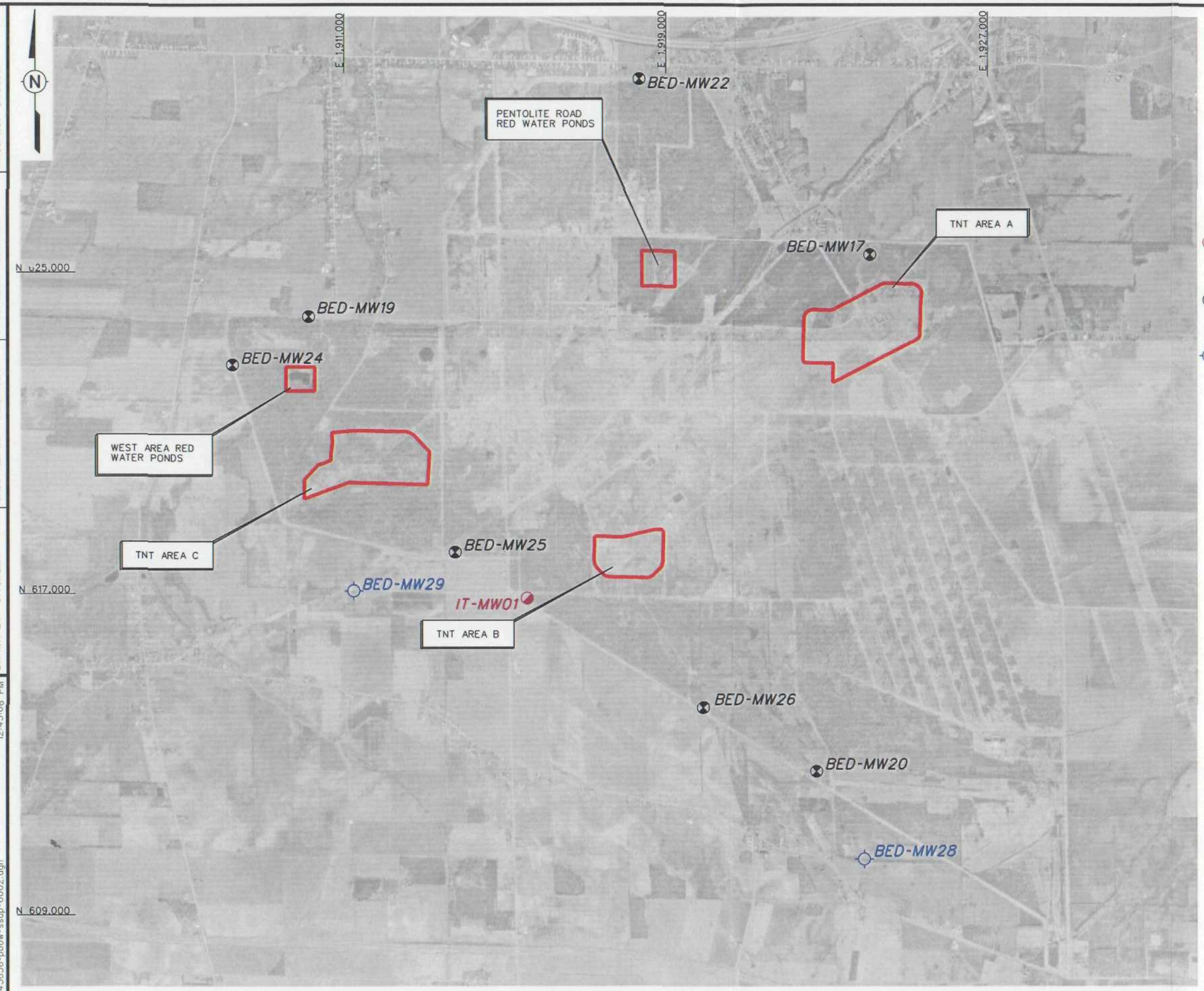
ctumlin
843656-pbow-ssap-0008.dgn



LEGEND

- AREAS OF CONCERN
- BUILDINGS
- RAILROAD
- SURFACE WATER
- DITCH
- FENCE (PBOW BOUNDARY)
- IT-MW01 — OVERBURDEN/SHALE MONITORING WELL LOCATION
- BED-MW20 — BEDROCK MONITORING WELL LOCATION
- BED-MW28 — PROPOSED BEDROCK MONITORING WELL LOCATION

SCALE

0 2500 5000 FEET

FIGURE 1-2

LOCATIONS OF AREAS OF CONCERN

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. NO.: 843656-pbow-ssap-0002.dgn
PROJ. NO.: 843656
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWNEY
INITIATOR: D.KESSLER
CADD REVIEW: C.BENTLEY
STARTING DATE: 12MAY03
DRAWN BY: C.TUMLIN

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07/24/03
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dhall
843656-pbow-ssap-0002.dgn

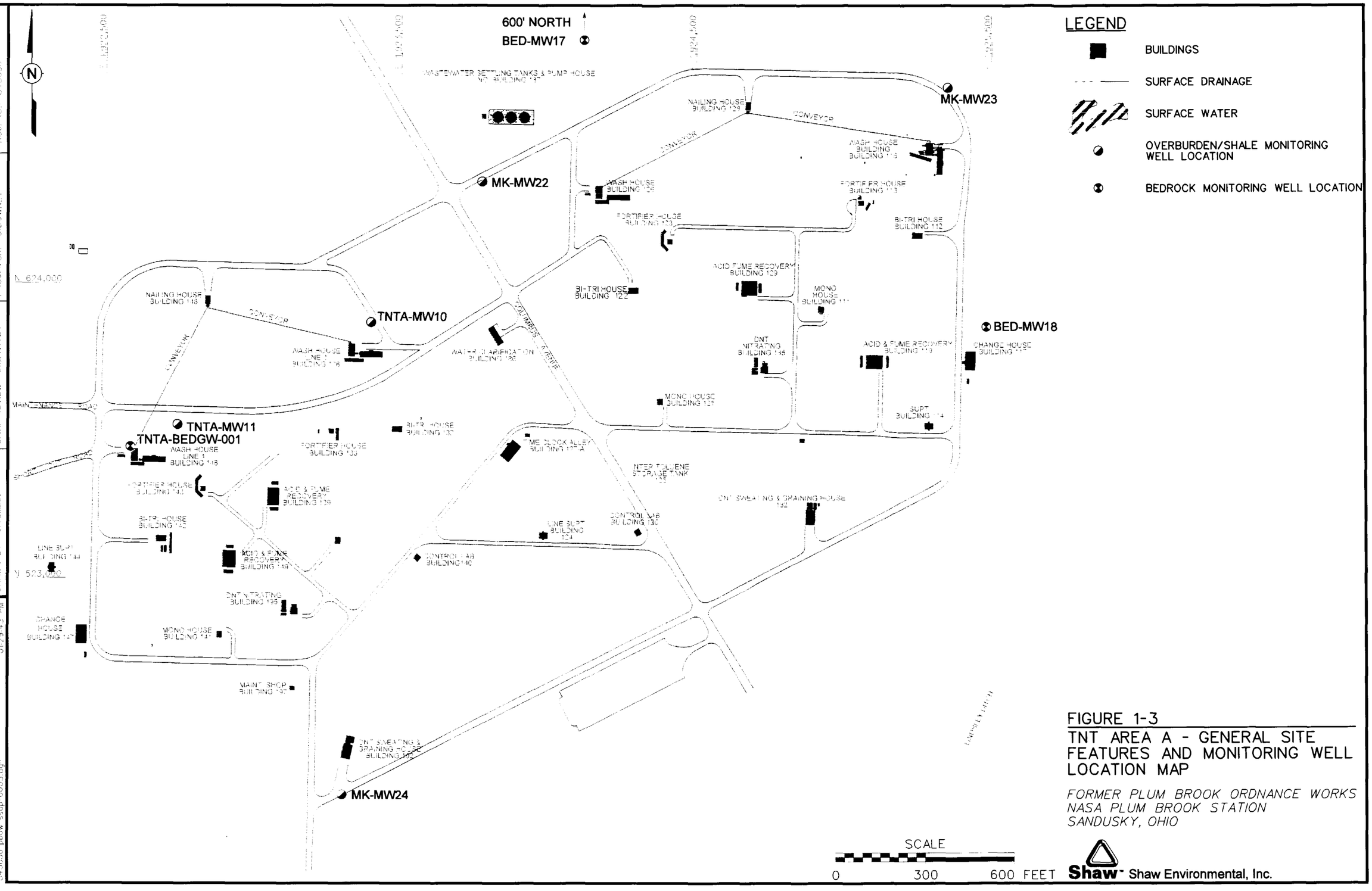
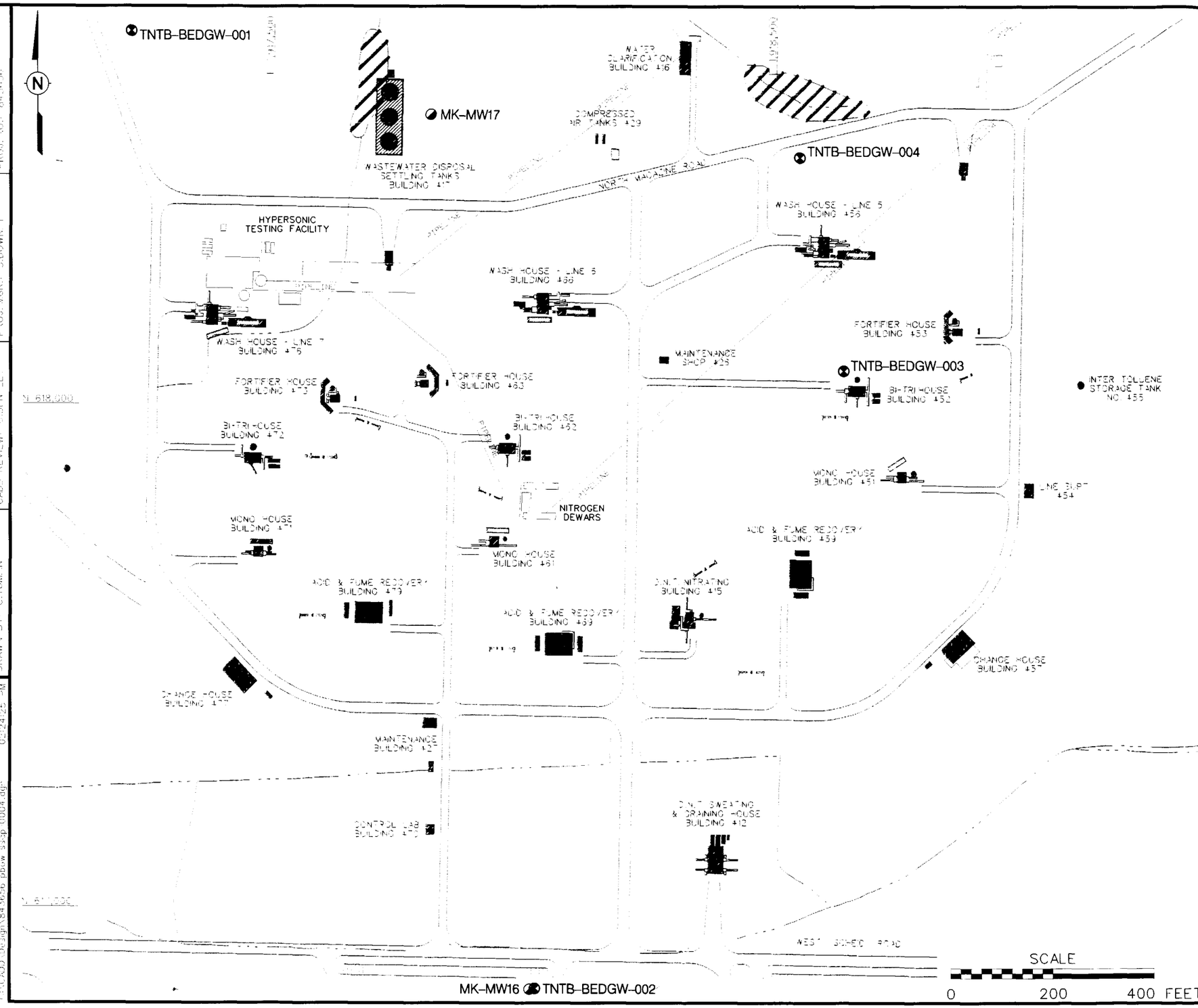


FIGURE 1-3

TNT AREA A - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental, Inc.



LEGEND

- BUILDINGS
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

NOTES

FIGURE 1-4

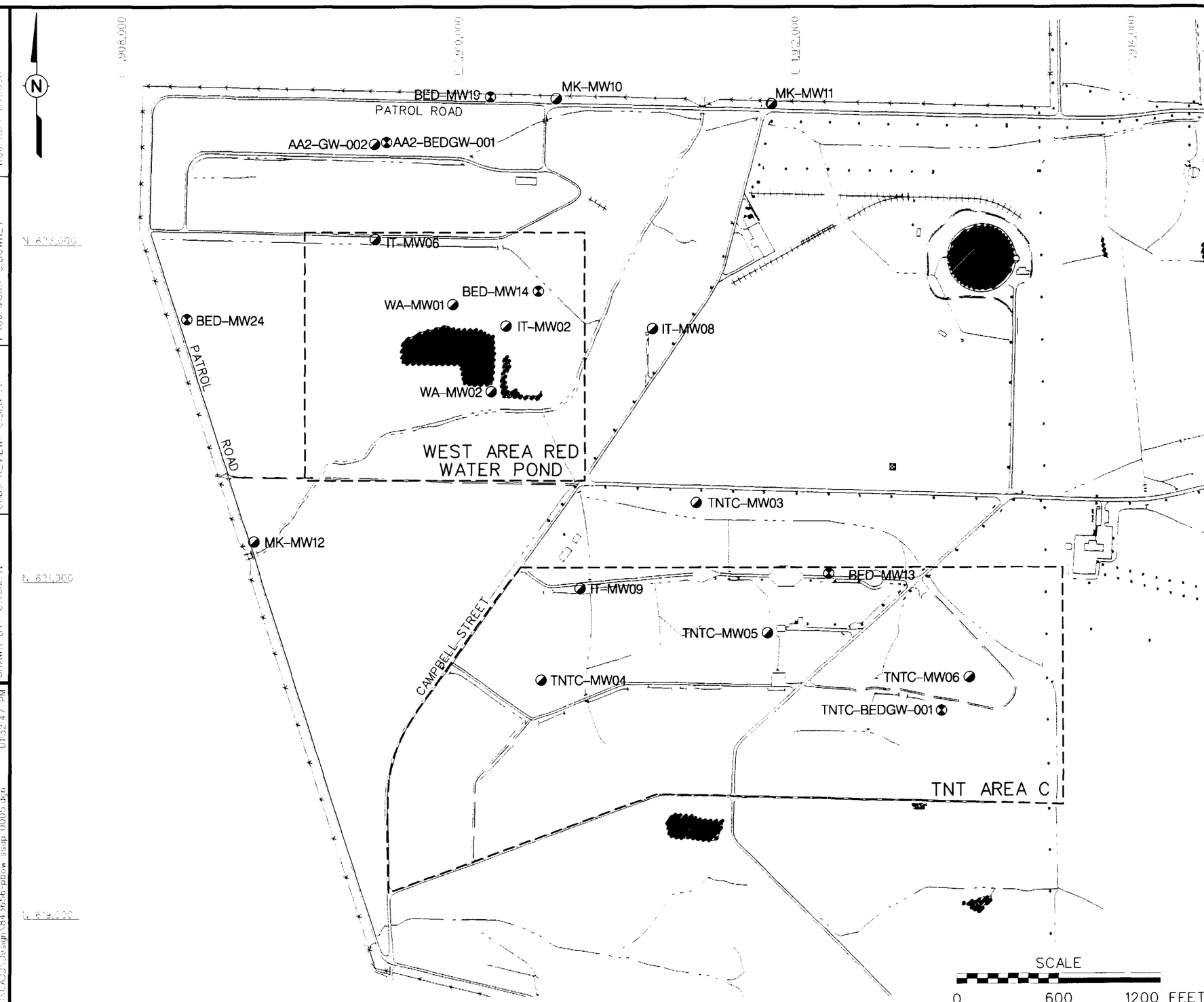
TNT AREA B - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

STARTING DATE: 12MAY03 | DRAWN BY: C.T.L.M.N | INITIATOR: D.FESSLER | CADD REVIEW: C.BENTLE | TECH REVIEW: D.FESSLER | PROJ. MGR.: S.DOWNEY | DWG. NO.: 845656 pbow ssap 0004.dgn | PROJ. NO.: 845656

CADD Design\845656 pbow ssap 0004.dgn
07/23/03 02:24:25 PM



LEGEND

- BUILDINGS
- FENCE (PBOW BOUNDARY)
- RAILROAD
- SURFACE DRAINAGE
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

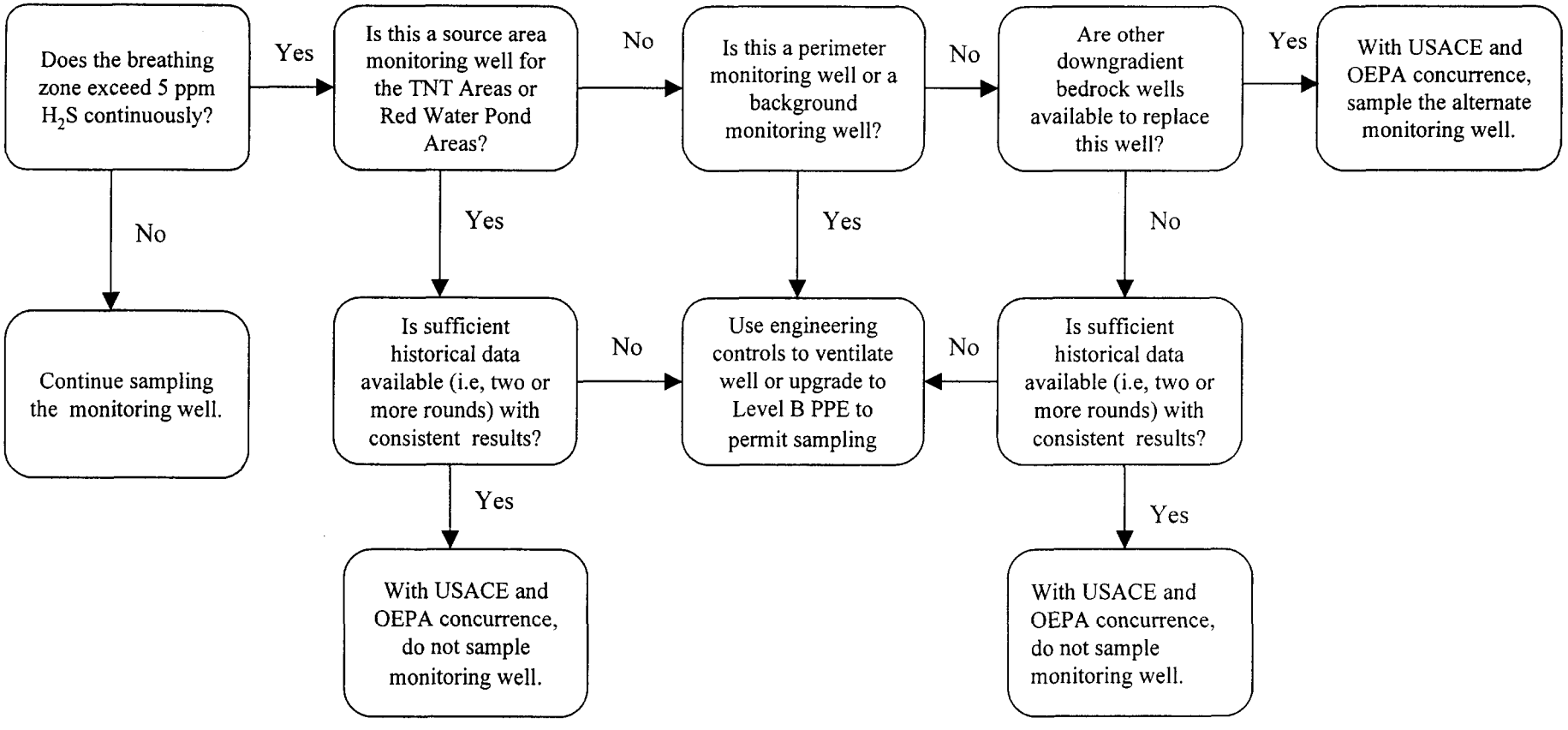
NOTES

FIGURE 1-5

WEST AREA RED WATER PONDS AND TNT AREA C - MONITORING WELL LOCATION MAP

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental, Inc.



ppm – parts per million.
H_2S – Hydrogen sulfide.
TNT – Trinitrotoluene.
USACE – U.S. Army Corps of Engineers.
OEPA – Ohio Environmental Protection Agency.
PPE – Personal protective equipment.

KN3\PBOW\CRI\SSHP\Fig5-1.ppt\7/24/03 3:43 PM

Shaw™ Shaw Environmental, Inc.

Figure 5-1
Process Flow Diagram for Bedrock Well Sampling

Former Plum Brook Ordnance Works
Sandusky, Ohio

RESPONSE TO COMMENTS
U.S. ARMY CORP OF ENGINEERS (CELRH-EC-R-D)
DRAFT - SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN (SSAP)/
SITE-SPECIFIC HEALTH AND SAFETY PLAN (SSHP)
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report dated May 2003)

Reference: Comments from the USACE, Nashville District, for the above noted report received June 19, 2003.

Draft SSAP Review Comments:

Comments of Jim Beaujon

Comment 1: **Page 1-20, final bullet item: Change "(report not yet been published)" to "(report in progress)".**

Response 1: "Report not yet been published" within text of the final bullet will be deleted as the report was distributed July 2003.

Comment 2: **Page 3-1, Section 3.2, 1st paragraph, last sentence: What soil interval (0-1' or 0-2') has been sampled on-site as our "surface soil" samples? That interval is the interval which will be sampled for these soil PAH background samples. Edit sentence as appropriate to replace "0 to 1 foot or 0 to 2 feet" with either "0 to 1 foot" or "0 to 2 feet".**

Response 2: Based upon the surface soil sampling conducted for the TNT A&C and TNT B remedial investigations, 0-1 foot of native soil was the target depth for surface soil samples. Therefore, the sentence will be edited to include 0-1 foot as the sampling depth.

Comment 3: **Section 3.3.1, edit as indicated in the following fragments: ... locations of 3 of the bedrock wells have been determined and are shown on Figure 1-7. ... WARWP/Acid ~~Acid~~ Area No. 2 (west of well PB-BED-MW24); [delete rest of list of general well locations and replace with following] the locations of the remaining 4 wells will be determined after additional data evaluation. ~~These 3~~ The 2 new off-site background ... flow directions ~~for the subsequent 5~~ and help determine where best to install the remaining 4 off-site bedrock wells. ~~to be installed in the effort.~~ ... The estimated depths for each new and relevant existing wells are presented in Table 3-1. ~~and the general location illustrated on Figure 1-7.~~ ...**

Response 3: Agreed. Sentence fragments within Section 3.3.1 will be edited as suggested, noting that only 2 wells are to be installed in the first phase of fieldwork and the remaining 5 wells will be installed at a later date.

Comment 4: **Page 3-4, Section 3.3.2, 2nd paragraph, 4th line into 5th line: The SSAP says the filter pack will be constructed with only an extra 2 feet above the screen. EM 1110-1-4000, page 5-5, Section 5-6, item *b* recommends 3 to 5 feet of extra filter pack. Consider increasing yours to 3 feet.**

Response 4: Agreed. In the 3rd sentence discussing the height of the filter pack sand above the well screen, the 2 feet height will be replaced by 3-5 feet.

Comment 5: **Section 3.3.2, last sentence of 2nd paragraph: Change to read "gallons of clean water <u>per 94 pound sack of cement</u>". Also, rather than Type I Portland Cement, (according to EM 1110-1-4000, page 3-9, section *c*.1) we might want to consider using Type II or V.**

Response 5: Agreed. The last sentence will be edited accordingly.

Comment 6: **Page 3-5, Section 3.3.2 continued, partial paragraph at top of page: EM 1110-1-4000, page 5-8, item 7 requires "painting of the protective casing must be done offsite, prior to installation". We've had other contractors have their subcontractors provide pre-painted protective casing. I believe the concern is that the volatile components of the paint may taint the well water if applied onsite.**

Response 6: Agreed. Shaw will have the subcontractors pre-paint the protective steel casing, if a protective casing is slipped over the PVC riser, at an area away from the monitoring well. In cases where the isolation casing is used as the protective steel casing, a temporary protective cover will be used over the isolation casing to prevent any paint from entering the monitoring well. Section 3.3.2 text will be edited accordingly.

Comment 7: **Page 3-7, Section 3.4, Edit first 2 lines as indicated: ... collected from <u>certain</u> existing and newly ... Proposed and existing <u>background</u> groundwater ...**

Response 7: Agreed. Edits will be made as suggested.

Comment 8: **Page 3-10, item beginning with "If the", end of last sentence: Edit to read- ... without purging<u>, after consultation with USACE</u>.**

Response 8: Agreed. "After consultation with the USACE" will be included.

Comment 9: **Page 3-12, Section 3.7, last sentence: How does SHAW propose to obtain clearance for/of private utility lines?**

Response 9: For clearance of private lines, the land or home owner will have to be questioned pertaining to knowledge of any lines that may be near the drilling location. In addition, the first 4 feet of each borehole will be posthole dug to

ensure no underground utilities are encountered near the surface. Appropriate additional information will be added to Section 3.7.

Comment 10: **Section 3.9, bullet items: In SAPs, which are meant to inform the reader what will be done, it's more appropriate to use declarative verbs such as "will" or "shall" rather than the passive form "should".**

Response 10: Agreed. "Should" will be replaced by "will" and "shall" where appropriate.

Comment 11: **Page 3-13, bullet item starting with "After": As written the text might be read as though additional grout won't be added unless the "unfilled portion is less than 15 feet". What I think you mean to say is that the additional grout will be added using a tremie pipe if the "unfilled portion" is greater than 15 feet. Edit for clarity.**

Response 11: Agreed. The sentence following the bullet will be changed to: "After 24 hours, the borehole/well will be checked for settlement and additional grout added if necessary. A tremie pipe will be used if the depth of the unfilled portion of the borehole is more than 15 feet.

Comment 12: **Page 4-1, 1st line of text: I know what discrete and composite samples are, explain what "fixed-base samples" are.**

Response 12: "Fixed-base samples" are samples that are sent to an off-site lab for definitive analysis. These are distinguished from on-site and off-site samples for screening analysis. The text will be modified to clarify this point.

Comment 13: **Page 4-1, Site Identification note *b*: The sites listed are not necessarily relevant to the sampling which will be done under this SSAP. What will be used for the offsite soil PAH background samples? What will be used for the offsite well samples?**

Response 13: The nomenclature for background wells will be consistent with that for other on-site background wells that have not been linked to any specific site. These wells will be named PB-BED-GWXX, with sequential numbering beginning with 28 (i.e, PB-BED-GW28 through PB-BED-GW34). The soil samples will be designated with "BCG" as the site code. This is consistent with previous background sampling at the Pentolite Road Red Water Pond ecological sampling.

Comment 14: **Table 3-1, New Bedrock Background Wells: Change as indicated-**
Upgradient Boundary, Southeast of well ~~PB-BED-MW26~~ BED-MW20
Upgradient Boundary, Southwest of ~~PB-BED-MW24~~ PB-BED-MW25

Response 14: Agreed. The changes will be incorporated as suggested.

Comment 15: **Table 3-1 and Figures: The wells referred to as "PB-BED-MW13", "PB-BED-MW15", "PB-BED-MW16", "PB-BED-MW17", "PB-BED-MW18", "PB-BED-MW19", and "PB-BED-MW20" have traditionally been referred to without the "PB". Delete the "PB-" on those well references/labels.**

Response 15: To permit a consistent presentation manner, the portion of the well ID beginning with "PB" will be removed from the text, tables, and figures (also see Response to Comments, U.S. Army Corp of Engineers [CELRH-EC-CE], Comments from Erich Guy, Comment 1).

Comment 16: **Figure 1-7, Legend: The overburden and bedrock label examples don't line up with their explanations.**

Response 16: The legend labels will be adjusted to line up with the identified explanation.

Comment 17: **Figure 2-1: a) There shouldn't be an arrow directly linking "Utility Clearance" and "Well Development". b) Change "Permeabilty Distribution" to "Permeability <u>Determination</u>". c) The background soil sampling flow chain shouldn't end with "Data Review".**

Response 17: Corrections and adjustments to Figure 2-1 will be made as suggested.

Comment 18: **Figure 3-2: Flush mount wells don't typically have barrier posts or 4' x 4' x 6" concrete pads. See Figure 5-5 on page 5-10 of EM 1110-1-4000.**

Response 18: True. The guard posts will be removed from Figure 3-2 and the monitoring well pad dimensions will be changed to 3' x 3' x 4".

Comment 19: **Are your well drilling, installation, and sealing plans in compliance with OEPA's revised (effective May 1, 2003) well drilling rules? Does Ohio require registration of these wells?**

Response 19: The well drilling, installation, and sealing plans are in compliance with OEPA's revised well drilling rules. Registration of the monitoring wells is necessary; however, the registration procedure is not implemented until after the wells have been installed. The drilling subcontractor has been contacted and is in the process of obtaining all forms prior to the initiation of drilling.

<u>Minor Typing Errors</u>

Page 1-5, paragraph middle of page, 7th line down: Change "all temporary except" to "all temporary piezometers except".

Agreed.

Page 1-19, paragraph beginning with "A BHHRA", 1st line: Change "exposure PRRWP" to "exposure to PRRWP".

Agreed.

Page 3-1, Section 3.1, 2nd paragraph, 2nd line: Change "to be by human" to "to be unaffected by human".

Agreed.

Page 3-4, last line: Change "falling." to "falling in".

Agreed.

Page 3-12, Section 3.7, 3rd line: Change "will obtained" to "will be obtained". Section 3.8, 2nd into 3rd line: Delete 2nd "station". Section 3.8- Insert a comma between "Lallier" and "NASA".

Agreed.

Page 4-2, Section 4.2, 2nd line: Table 3-2 summarizes the analytical requirements not Table 4-1 (there is no Table 4-1).

Agreed.

<u>Comments of Becky Terry</u>

Comment 1: **General. Throughout Section 1. References are made to Shaw before Shaw acquired IT Corporation. The documents produced by IT should be referenced as such.**

Response 1: All references to work performed by IT (renamed to Shaw) prior to contract novation March 13, 2003, will changed to IT.

Comment 2: **Section 1.2.1.1. Page 1-3. Fourth paragraph. Please provide the conclusions from the 1996 PBOW investigation.**

Response 2: Analytical results from the 1996 groundwater investigation are already included. They are compared with the with the analytical results from the 1997 investigation in the 5th paragraph on page 1-3 and the 1st paragraph on page 1-4.

Comment 3: **Page 1-4. Last paragraph. Please edit next to last full sentence on page that begins with "Analytical results".**

Response 3: Sentence "Analytical results listed were the highest of each sample" will be removed from the paragraph.

Comment 4: **Page 1-5. First paragraph. Last sentence. I assume that the last sentence is referring to the surface sample TNT concentration. Clarify.**

Response 4: The sentence will be rewritten as "The TNT concentration from the surface water sample was 11,000 ug/L.

Comment 5: **Page 1-5. Second paragraph. Sentence that begins with " 2,4-DNT". Edit sentence.**

Response 5: "Piezometers" will be inserted between "temporary" and "except".

Comment 6: **Page 1-6. First full paragraph. First sentence. Edit.**

Response 6: Agreed. Following "performed for...TNTA for possible human exposure to soil, ..." will be inserted into the 1st sentence for clarification.

Comment 7: **Page 1-7. First full paragraph. Third sentence. Delete and edit the fourth sentence to state the following: Surface water and sediment sample SW07 and SD07...**

Response 7: Agreed, but for clarity, the third sentence will be deleted and "surface water sample" and "sediment sample" will proceed sample IDs SW07 and SD07. The same will be performed for SW08 and SD08 in the 5th sentence.

Comment 8: **Page 3-6. Fourth bullet. One of the advantages of the low-flow sampling procedure is that the procedure does not use pre-calculated purge volumes to determine when samples can be collected. Samples are collected when water level and field parameters stabilize during pumping. Suggest editing this sentence.**

Response 8: True but this section (3.3.3 Monitoring Well Development) is presenting the criteria that must be used during well development. No change will be made.

Comment 9: **Page 6-1. Laboratory Waste. An on-site lab is not planned for this phase of work at PBOW. Suggest removing this paragraph from the discussion.**

Response 9: Agreed. This section (6.4) will be removed from the report.

Comments of Lannae Long:

Lannae Long had no comments for the SSAP.

Draft SSHP Review Comments:

The Nashville - USACE Safety Office has approved the Draft as written and the Nashville – USACE has no comments.

RESPONSE TO COMMENTS
OHIO ENVIRONMENTAL PROTECTION AGENCY
DRAFT - SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN (SSAP)/
SITE-SPECIFIC HEALTH AND SAFETY PLAN (SSHP)
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report dated May 2003)

Reference: Comments from Ron Nabors of Ohio EPA, for the above noted report, received from Ms Linda Ingram July 1, 2003.

Draft SSAP Review Comments:

Comment 1 **Shaw notes on pages 3-3 and 3-8 of the draft SAP that of the seven new bedrock monitoring wells that are proposed to be installed at the NPBS as part of the sitewide GWI, two will be new background bedrock wells and five will be offsite downgradient bedrock wells. However, the first paragraph on page 3-4 draft SAP states that 3 new offsite background bedrock wells will be installed. Shaw should revise the text appropriately to eliminate this discrepancy.**

Response: Agreed. One bedrock monitoring well (BED-MW30) is planned to be installed west of the West Area Red Water Pond to support interpretation of groundwater flow direction. Given the uncertainty in groundwater flow direction in this area, it is unclear at this time whether the well is downgradient, crossgradient, or upgradient of the West Area Red Water Pond. Data from this well will be used to determine groundwater flow direction and groundwater quality. As noted, this well is referred to as both a "background" well and a "downgradient" well. For the workplan, only the two known upgradient locations will be referred to as "background" and the sections in question revised to reflect this change. Please note that due to Right of Entry issues, only the two background wells will be installed under the first phase of fieldwork.

Comment 2 **Ohio EPA requests that Shaw prepare a figure noting those wells that have been installed and/or sampled at the NPBS specifically in support of the sitewide GWI. Ohio EPA is requesting the generation of the above figure due to the number of active units under investigation and the sheer number of onsite and offsite monitoring wells and sampling events which have been completed at the NPBS to date. The requested figure will help to facilitate the ultimate completion of the investigation. Ohio EPA also requests that Shaw provide a summary table noting completed sampling dates and corresponding wells since the inception of the sitewide GWI.**

Response: The figure and table requested have been provided under the Quarterly Sampling Reports. A summary table and figure showing all well locations sampled under the groundwater RI will be provided to OEPA under separate cover.

RESPONSE TO COMMENTS
U.S. ARMY CORP OF ENGINEERS (CELRH-EC-CE)
DRAFT - SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN (SSAP)/
SITE-SPECIFIC HEALTH AND SAFETY PLAN (SSHP)
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report dated May 2003)

Reference: Comments from Frank Albert LRH, for the above noted report received from Ms Linda Ingram June 16, 2003.

Draft SSAP Review Comments:

Comment 1: **List of Acronyms. RDX has been defined as *Research and Development Explosive*; however, the ATSDR defines RDX as *Royal Demolition Explosive*. Please verify.**

Response 1: A thorough search was performed to obtain the correct definition for the acronym of RDX (cyclotrimethylene_trinitramine). As noted by Comment 1 and results of the search, several different acronyms for RDX were found. The concluding acronym for RDX came from 2 sources. One source is found at a web site link (http://holston-aap.com/hsaap/history.htm) for Holston Army Ammunition Plant (HSAAP) located in Kingsport, TN. HSAAP was one of the first and one of the main manufacturing facilities of RDX. The second source came from a Los Alamos Scientific Library (LASL) Explosives Property Data manual. LASL used and worked with RDX extensively for production of weapons. Both sources identify RDX as **Research Department Explosive**.

RDX was initially discovered in 1890 by a German (Hans Henning) who first offered it as a medicine. It was not until 1920 when it was found to have explosive properties. For many years, RDX was used mainly by the British government for demolition and warfare activities. Because the British manufactured RDX in large quantities and found that it produced more of a "punch" than TNT, RDX became "earmarked" with the British and therefore obtained the slang term "Royal Demolition Explosive". HMX also has a similar slang acronym related to the British, "Her Majesty's Explosive" whereas the correct acronym is "High Melting Explosive".

Comment 2: **Section 1.2.1.2, last paragraph. For reference, it is recommended that it is noted that the USACE initiated the referenced removal action.**

Response 2: Agreed. In the last paragraph of Section 1.2.1.2, the sentence will be restructured as follows "In September 2002, the USACE initiated the removal action of contaminated soil at TNTB".

Comment 3: **Section 1.2.2.2, last paragraph, last sentence. For reference, it is recommended that it is noted that the USACE initiated the referenced**

removal action. Note, the action commenced in the fall/winter 2002 (Lisa Humphreys has actual dates), and disposal of the excavated soil occurred in April 2003.

Response 3: Agreed. In the last paragraph of Section 1.2.2.2, the sentence will be restructured as follows "In the fall/winter 2002, the USACE initiated the removal action of contaminated soil at the PRRWP".

Comment 4: **Section 1.2.4, 1st paragraph. Recommend stating that the USACE abandoned the well.**

Response 4: Agreed. The last sentence of the first paragraph will be restructured to include "by the USACE" following the word "abandoned".

Comment 5: **Section 3.3.1. A brief explanation as to why the 5 downgradient wells have not been located is recommended (if questions arise as to why only the 3 upgradient wells have been located).**

Response 5: Agreed. The paragraph has been edited to provide an explanation for the location of the remaining wells (see also Response to Comments, U.S. Army Corp of Engineers - CELRH-EC-R-D, Comments of Jim Beaujon, Comment 3).

Draft SSHP Review Comments:

Comment 1: **List of Acronyms. SSHP should be defined as *Site-specific Safety and Health Plan.***

Response 1: Agreed. "Specific" will be included in the SSHP acronym.

Comment 2: **General comment. It is noted that this SSHP is an addendum to the Site Safety and Health Plan, which covers work throughout the entire PBOW project. However, it may be good to mention is this document Plum Brook Station safety protocol, i.e., do not contact 911 (all emergencies must be coordinated through the site security guards), etc.**

Response 2: Agreed. In emergencies for work conducted onsite, 911 should not be contacted for emergencies when an accident occurs within the PBOW property boundaries. Since most of this work will be conducted outside of the PBOW security area, 911 will be the initial contact for immediate emergency attention in those situations. If an accident occurs within PBOW boundaries, all emergencies will be coordinated through the site security. This information will be added to the SSHP emergency contact list.

RESPONSE TO COMMENTS
U.S. ARMY CORP OF ENGINEERS (CELRH-EC-CE)
DRAFT - SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN (SSAP)/
SITE-SPECIFIC HEALTH AND SAFETY PLAN (SSHP)
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report dated May 2003)

Reference: Comments from Erich Guy of LRH, for the above noted report, received from Ms Linda Ingram June 16, 2003.

Draft SSAP Review Comments:

Comment 1: **Section 1.2.1.1: in paragraph 5, wells are referred to as TNTA-MW10 and TNTA-MW11, whereas in Figure 1-3 the same wells are referred to as: PB-TNTA-MW10 and PB-TNTA-MW11. In paragraph 5, wells are referred to as BED-MW17 and BED-MW18, whereas in Figure 1-3 and paragraph 6, the same wells are referred to as PB-BED-MW17 and PB-BED-MW18, and in paragraph 9, the well PB-BED-18 is referred to. The wells should be referred to in a consistent manner.**

Response 1: Agreed. The official name of most of the monitoring wells begins with a "PB". The "PB" designation was removed from the text to eliminate redundancy. In order to follow a consistent manner, "PB" will be removed from the text, tables, and figures (also see Response to Comments, U.S. Army Corp of Engineers [CELRH-EC-R-D], Comments from Jim Beaujon, Comment 15).

Comment 2: **Section 1.2.1.2: in paragraph 11 it is stated that TNTB-BEDGW-002 was installed southeast of TNTB, however this well is actually located to the immediate south of TNTB (see Figure 1-4).**

Response 2: Agreed. The sentence will be changed to reflect that the monitoring well is immediately south of TNTB.

Comment 3: **Section 1.2.4: Instead of simply stating the well was abandoned, mention that well PB-BED-MW27 was closed in accordance with State of Ohio (OEPA) well closure guidelines.**

Response 3: Agreed. The portion of the sentence "abandoned in January 2003" will be replaced by "closed in January 2003 in accordance with Ohio Environmental Protection Agency (OEPA) well closure guidelines due to obnoxious hydrogen sulfide odors (rotten egg)".

Comment 4: **Section 2.4.3: Remove period after "Contaminants of Concern" in bulleted list.**

Response 4: Agreed. The period will be removed after "Contaminants of Concern" in the bulleted listed in Section 2.4.3.

Comment 5: **Section 3.2: In the third paragraph, indicate that in a future report (or as an appendix to a future report) monitoring well construction schematics and geologic logs will be presented.**

Response 5: Agreed. A sentence indicating that the borelogs and well construction diagrams will be included in an appendix of a future report will be included.

Comment 6: **Section 3.3.1: In the second to last sentence clarify that only the locations of the 3 new wells that have been decided on are shown in Figure 1.7.**

Response 6: The sentence has been adjusted and the well location shown by Figure 1-7 was moved to the end of the second sentence. Because of Right of Entry issues, only 2 monitoring wells will be installed during the first phase of fieldwork. The text will be modified to reflect this change.

Comment 7: **Why are many recent references from Shaw cited as IT Corporation documents in the text and listed as such in section 7.0? For instance, a review copy of the 2002 Groundwater Data Summary and Evaluation Report that is referenced does not have IT written on it anywhere. Referencing documents in this manner will likely cause confusion for people involved with the project in the future.**

Response 7: IT Corporation was purchased by Shaw Environmental, Inc. on June 6, 2002 and novation activities were completed March 13, 2003. Past reports written by IT Corporation must remain "IT Corporation" because they cannot be republished and resubmitted. With a new company name, after March 13, 2003, all work completed and any reports published must reflect the new owners name Shaw Environmental, Inc. (Shaw).

Comment 8: **Place an approximate scale on the vicinity map in Figure 1-1.**

Response 8: Figure 1-1 is "Vicinity Map" with the purpose of only showing the location of PBOW in relation to other local features. The map is not to scale. Figure 1-2 is a more detailed map, showing an accurate scale.

<u>Draft SSHP Review Comments:</u>

Comment 1: **I recall that emergency phone numbers for on-site visitors to use are provided by the PBOW guard station. Ensure that these phone numbers are listed in the emergency contacts list for situations in which people working on-site have a cell phone but do not have 2-way radios.**

Response 1: Only one number should be dialed for emergencies when working on base. It is a direct line to the emergency communications person at the guardhouse. It is (419) 621-3222 and will be included on the list.

Comment 2: **Section 1.0, Project Objective: Remove the extra tab space after the third bullet.**

Response 2: The extra tab space will be removed after the third bullet as suggested.

Comment 3: **Section 1.0, Personnel Requirements: Provide reference (i.e. the date) for the "sitewide SHP for investigations at PBOW" that is referred to in this section.**

Response 3: The date of the site-wide SHP was 1996. The reference (IT, 1996b) is included in Section 7.0 of the SSAP. This information will be added to the sentence.

Comment 4: **Place a scale on the vicinity map in Figure 1-1.**

Response 4: Figure 1-1 is "Vicinity Map" with the purpose of only showing the location of PBOW in relation to other local features. The map is not to scale. Figure 1-2 is a more detailed map, showing emergency routes along with an accurate scale.

RESPONSE TO COMMENTS
U.S. ARMY CORP OF ENGINEERS (CELRH-EC-R-D)
DRAFT - SITE-SPECIFIC SAMPLING AND ANALYSIS PLAN (SSAP)/
SITE-SPECIFIC HEALTH AND SAFETY PLAN (SSHP)
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report dated May 2003)

Reference: Comments from HTRW-CX, for the above noted report, received June 23, 2003.

Draft SSAP Review Comments:

Comments from Joseph Solsky:

Comment 1: **SSAP - Tables 3-2 and 5-1: It would be recommended that the following changes be made to this table: For Groundwater: (1) For the TCL Semivolatile Organic Compounds, the extraction method 3510C is listed. It is generally recommended that method 3520C be used since it is a much more rigorous and efficient method for extracting these analytes from water samples, especially for those samples that may contain moderate levels of interferents. (2) For the Nitroaromatic compounds, the analytical method 8330M is listed. A short description should be presented as to what modifications are being made. A newer version of the method (8330A) is now available and should be considered for use since the newer version incorporates a more efficient water extraction procedure. (3) For the TAL Metals (T/D), the prep/analytical method listed is 3005A/6010B/7470A. A newer version of the method (6010C) is now available and should be considered for use. For Soil: (1) For the Poly-Aromatic Hydrocarbons, the methods 5035/8260B are listed. These are methods for the volatile organic compounds and should be replaced by 3540C/8270C or 3540C/8310. (2) For the Nitroaromatic compounds, the analytical method 8330 is listed. A newer version of the method (8330A) is now available and should be considered for use. (3) For the TAL Metals (T/D), the prep/analytical method listed is 3005A/6010B/7471A. A newer version of the method (6010C and 7471B) is now available and should be considered for use. For Soil IDW: (1) For the TCLP Volatile Organic Compounds, the preparative method was omitted and should be included (5030B). (2) For the TCLP Semivolatile Organic Compounds, the preparative method was omitted and should be included (3520C). (3) For the TCLP Metals, the preparative method was omitted and should be included (3005A). A newer version of the method (6010C) is now available and should be considered for use.**

Response 1: Noted. The choice of the analytical methods used is based on three factors:

- Methods requested by the client in the scope of work.
- USACE validation of laboratories and specific methods.
- Currently promulgated analytical methods.

Although Shaw is willing to consider the use of all available methods, only the methods presented in the SSAP meet all the criteria listed.
Response Groundwater (1): Historically, the separatory funnel method has been sufficient to extract the water samples from PBOW. Since the Shell document allows the use of both methods and the SOW lists 3510C as the extraction method, the SSAP will remain unchanged.
Response Groundwater (2): The modified method 8330 uses a solid-phase extraction procedure instead of the salting out extraction procedure for low-level water samples. Since the analysis is the same, the tables will be updated to reflect the extraction (3535) and the analysis (8330) methods.
Response Soil (1): The methods for PAHs will be updated to 3540C/8310.
Response Soil IDW: The appropriate preparative methods for the TCLP analyses will be added to the tables.

Comment 2: **SSAP - Tables 3-2 and 5-1: It would be recommended that the list of target analytes be specifically stated for the Explosives and PAHs to ensure that the appropriate target analytes are analyzed for and reported for this project.**

Response 2: Agree. The parameter list for method 8330 is listed in the original QAPP. Two compounds have been added to the list and will be added to the table within section 2.3. The parameter list for 8310 will be added as a footnote to Table 3-2.

Comment 3: **SSAP - Section 7.0 (References): It would be recommended that the latest version of the USACE 'SHELL' document be referenced in this section.**

Response 3: Agree. Section 4-2 will be updated to state that laboratories are required to adhere to criteria outlined in the Shell document. USACE EM 200-1-3 will be referenced in Section 7.0

Comment 4: **General: This document is primarily based on an original QAPP which was written and reviewed in 1996. As a consequence many of the specific details are not presented in this site-specific document such that a thorough review could be conducted. The original document was created many years ago and significant updates have taken place regarding USACE CDQM policy (the SHELL did not exist at that time), SW846 methodologies, and data validation strategies. As a consequence it would be recommended that the original QAPP be periodically reviewed and updated to ensure that current policies and strategies are being implemented.**

Response 4: Agree. The 1996 QAPP was reviewed. Updated differences are listed in the table within Section 2.3 (QAPP Review).

<u>Comments from Steve White</u>

Comment 1: **2.4.3; This section should reference the following USACE guidance document: Publication Number: EM 1110-1-1200; Title: Engineering and Design - Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects n can be downloaded from:** http://www.usace.army.mil/usace-docs/eng-manuals/em1110-1-1200/toc.htm

Response 1: Agreed. The reference will be included.

Comment 2: **3.3.1; You are probably sick of hearing the comment that there are two new off-site background wells not three.**

Response 2: A change to the number has been made in Section 3.3.1 (also see Comment 3 by Jim Beaujon, Response to Comments - U.S. Army Corp of Engineers (CELRH-EC-R-D).

Comment 3: **3.3.3; I recommend that you consider adding a predevelopment step immediately after the filter pack has been added, but before the bentonite is added. This has the advantage of surging and potentially compacting the filter pack as it sets up around the screen and also eliminating any bridging. It would then be possible to add additional sane to achieve the desired elevation. In addition the drilling fluids and other fines associated with drilling can be more easily removed when fresh and they have not had a chance to set up. During this stage the only thing necessary to record is the volume of fluid removed, as the parameters are irrelevant until the final development. This step often leads to faster and better development.**

Response 3: Agreed. A section for predevelopment will be included (new 3.3.3 section).

Comment 4: **3.4.2; Consider including a requirement to have copies of the well installation diagrams to assist in determining saturated well volume and where to install the inlet for the low-flow pump.**

Response 4: Agreed. Well construction diagrams will be included as a bullet in equipment required list.

Draft SSHP Review Comments:

Comments From Rod Dolton

Comment 1: **Paragraph 3.0, Page 4, Level C: Change reference to HEPA filter to N, R or P 100 filters. Strongly suggest that saran-coated Tyvek be replaced with permeable clothing as the major contaminant of concern is H2S, an inhalation hazard resulting in a need for upgraded respiratory protection, not requiring chemical splash protection. The other**

contaminants are semi-volatiles, which represent more of a dust hazard where permeable Tyvek or Kleenguard would be adequate. When there is a need to go beyond level D modified because of the H2S concern, go with the respiratory protection and do not use the impermeable clothing, which just exacerbates the whole heat stress hazard issue when there is no need.

Response 1: Respirator cartridge reference was amended to "organic vapors/aid gases/P100 (Survivair Number TC-84A-0444)". Saran coated Tyvek was amended to state "permeable Tyvek".

Comment 2: **Paragraph 3.0, Page 4, Level B: See Comment # 1.**

Response 2: It is unlikely Shaw will upgrade to Level B PPE for the collection of groundwater samples. Figure 1-3 Process Flow Diagram will be followed to determine if data from the well exhibiting elevated H_2S is necessary. However, the use of impermeable clothing for H_2S environments around wells in excess of the action level has been amended to "permeable Tyvek".

Comment 3: **Paragraph 3.0, Page 5, Personal Decontamination: Station # 3: Rewrite to state what to do with the disposables.**

Response 3: A sentence will be included at the end of the Station 3 paragraph saying "Disposable personnel protective equipment that is generated will be double-bagged and disposed of in on-site dumpsters".

Comment 4: **Paragraph 4.0 Site Monitoring, Page 6, 3rd subparagraph, Rewrite to require the PID be equipped with a lamp power > 11.0 so as to be responsive to one of the contaminants, TNT.**

Response 4: Trinitrotoluene has an eV of 10.59. The sentence will be changed to "...lamp power of at least 10.6 eV or 11.7 will .....".

Comment 5: **Table 4-1: Level C: add H2S to Analytes and explain why you will bypass Level C and go directly to Level B with high concentrations of H2S gas present.**

Response 5: H2S can not be added to Level C PPE because there is no respirator that can remove hydrogen sulfide vapors. This information will be added as a footnote to Table 4-1.

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LEGEND

— — —	GENERALIZED AREA OF PROPOSED SOIL BORINGS/MONITORING WELLS
IT-MW01	OVERBURDEN/SHALE MONITORING WELL LOCATION
BED-MW25	BEDROCK MONITORING WELL LOCATION
BED-MW29	PROPOSED BEDROCK MONITORING WELL LOCATION (ALL LOCATIONS ARE APPROXIMATE PENDING RIGHT OF ENTRY APPROVAL)

REFERENCE:

DOQQ NE QUARTER CASTELLA, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SE QUARTER CASTELLA, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ NE QUARTER BELLEVUE, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SE QUARTER BELLEVUE, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ NW QUARTER SANDUSKY, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SW QUARTER SANDUSKY, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ NE QUARTER SANDUSKY, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SE QUARTER SANDUSKY, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ NW QUARTER KIMBALL, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SW QUARTER KIMBALL, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ NE QUARTER KIMBALL, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.
DOQQ SE QUARTER KIMBALL, OHIO 7.5 QUADRANGLE DATED: 09/18/2000.

DOQQ - DIGITAL ORTHOPHOTO QUARTER QUADRANGLE.

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
08MAY03	D. KESSLER		C. TUMLIN		S. DOWNEY

Shaw Environmental, Inc.

CONTINUED GROUNDWATER REMEDIAL INVESTIGATION
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 1-7
AERIAL PHOTOGRAPH OF GENERAL AREA OF PROPOSED SOIL BORINGS AND BEDROCK MONITORING WELL LOCATIONS

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	PBOW-SSAP-0007	0