

2.0 STUDY AREA INVESTIGATIONS

This section describes the field and analytical methods implemented during the Phase II RI to collect and analyze data needed to meet the DQOs developed in the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Grounds and Determination of Facility-Wide Background at RVAAP* (USACE 1998a). The field and analytical programs were conducted in accordance with the *RVAAP Facility-Wide SAP* (USACE 1996a) and the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Grounds and Determination of Facility-Wide Background at RVAAP* (USACE 1998a). Investigation objectives, rationale, sampling methods, and sampling locations are discussed in this section.

Field activities were conducted in April and May of 1998. Field investigation activities included surface (171 samples) and subsurface (41 samples) soil sampling; surface water (1 sample) and sediment (19 samples) sampling in streams and Mack's Pond; and the installation, sampling, and testing of groundwater monitoring wells at WBG. Four existing monitoring wells at WBG were also sampled (10 samples total). The field program also included soil sampling (17 surface and 29 subsurface soil samples); monitoring well installation, sampling, and testing at 14 locations (16 samples); and surface water (8 samples) and sediment (9 samples) sampling at 7 locations for further characterization of facility-wide background conditions at RVAAP. Phase II RI sample locations at WBG were approved by representatives of the RVAAP, OEPA, and USACE, based on the results of the Phase I RI and other studies conducted at WBG. The rationales for each component of the field program are described in the following sections.

2.1 SURFACE AND CULTURAL FEATURES

The topography at WBG is characterized by gently undulating contours that decrease in elevation from west to east. Elevations at the WBG vary from 312.3 to 341.2 m (993.2 to 1084.9 ft) above mean sea level (amsl) across the AOC. The topography of the site was mapped by the USACE in February 1998, on a 2-ft contour interval, with an accuracy of 0.02 ft. This survey is the basis for topography presented in figures in this Phase II RI Report. Data from a March 1998 aerial photographic survey, obtained by the USACE, were used to supplement the topographic survey.

Surface water drainage flows mainly from west to east across the WBG. The northwest portion of the burning grounds drains to the north, as seen by the stream draining Pads #59 and 60 and flowing towards the pistol range. Three other small streams traverse the AOC, all of which are tributaries to Sand Creek, a major drainage feature at RVAAP. One pond, known as Mack's Pond, is located in the southwest quadrant of WBG, near its southern perimeter. Beaver ponds are located in the southeast quadrant of, as well as north of, the WBG, and their extents vary from year to year.

Cultural features at WBG consist mainly of gravel or dirt roads, running east to west, that are tied together by connecting roads at the eastern and western ends of the site. George Road roughly bisects WBG. The burning pads are arrayed along the roads. For each road, burning pads are only located on one side of the road. Many of the pads are clearly visible, because they are typically constructed of a platform of soil and slag that remains partially unvegetated, or they are bordered by earthen berms. However, other pads are more subdued in appearance, with little or no slag visible on the ground surface, and no berms to define their boundaries. Pad #70 does not have the typical burning pad features at all, but rather is the site of several large dirt and debris mounds that are 1.89- to 2.51-m (6- to 8-ft) high. WBG is bounded on its eastern end by a railroad spur that runs between several storage blocks.

Several buildings are still standing at WBG. Buildings 1601, 1602, and 1603 are concrete bunkers located on Pallet Road B (see **Figure 1-3**). Building 1601 is a RCRA unit currently in the process of closure for the

former storage of ash residues from the burning trays at Pad #37. The other two bunkers are currently not in use. The Deactivation Furnace Area at Pad #45 is another RCRA unit in the process of closure. The building consists of a wooden structure with transite roofing and a free-standing wall. The building is scheduled to be demolished and removed in the process of closure under RCRA. Building T-3403 stands next to the Deactivation Furnace. Building T-4301 has been scheduled for IRP action. Pad #37 is the OBG and is also a RCRA unit scheduled to be closed. This unit consisted of a slag burning pad and four metal trays with refractory lining. The trays have been removed, decontaminated, and transported offsite and melted down as part of the closure requirements.

Aerial photos dated April 16, 1952 were available from RVAAP's archives and indicate that the eastern half of the site was most intensively used for burning of explosives and other materials. Design and utilities drawings dating from the 1940s show a popping furnace was in use before the present Deactivation Furnace was constructed in the middle 1960s. Portions of the original popping furnace located about 6 m (20 ft) west of the present Deactivation Furnace are still present.

2.2 CONTAMINANT SOURCE INVESTIGATIONS

Five previous investigations have been conducted at the WBG. With the exception of the Phase I RI, most studies focused on small subsets of the 70 burning pads at WBG. As described in Section 1.2.3, the USACE study (1997b) focused on Pads #37 and 67 only. The USAEHA evaluation focused on Pads #37 through 40, 52, 58, 59, 60, 65, 66, and 67, and Road D Ditch. These investigations indicate high concentrations of TNT, RDX, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), and DNT in surface soils, as well as elevated concentrations of metals such as arsenic, lead, and cadmium.

The objective of the Phase I RI was to confirm whether contamination was present in the surface soils and ditch sediments as a result of open burning of explosives and waste at WBG. The Phase I study also included a characterization of naturally occurring background levels of inorganic analytes in surface soils, subsurface soils, and ditch sediment, using samples from 15 locations located outside the process areas in each of five load lines (USACE 1997a). The Phase I RI background soil sampling effort established background concentration criteria for 11 of the known process-related metals at RVAAP. These metals included aluminum, arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc. The Phase I RI background sample data are incorporated into the Phase II RI background data for soils in this report.

The RCRA Field Investigation conducted in November 1997 (USACE 1998b) included the collection of soil samples and two samples of slag at the Deactivation Furnace Area and Building 1601. Only the two samples collected inside the Deactivation Furnace Area RCRA unit boundary were analyzed for chemical constituents. The samples collected at Building 1601 were analyzed for geotechnical properties only. TAL metals and explosives were analyzed in samples collected to a depth of 3 m (10 ft) bgs at the Deactivation Furnace Area, including a surface composite soil sample at each location. No explosives or propellants were identified in the soils. The highest concentrations of metals were found in the 0- to 0.6-m (0- to 2-ft) or 1.2- to 1.9-m (4- to 6-ft) intervals. No analytic sampling was performed below 3 and 5 m (10 and 16 ft), respectively, at the two borings. Arsenic and zinc appeared to be present in surface soils at concentrations greater than their natural abundance in soils. A Geoprobe device was used to collect samples for lithologic logging and to estimate the depth to bedrock and to groundwater at both the Deactivation Furnace Area and Building 1601. The glacial tills beneath the Deactivation Furnace Area were found to be at least 13.5 m (43 ft) thick. No lithologic information is available from greater depths. Saturated zones were present in unconsolidated sand lenses at both locations, at 2.83 and 3.77 m (9.6 and 12 ft) bgs.

Groundwater monitoring results are available from 15 rounds of well sampling from the four wells (OBG-1, -2, -3, and -4) at the RCRA-regulated OBG at Pad #37. Two sampling events were conducted in 1992, and quarterly sampling events have been conducted each year thereafter, to monitor contamination in groundwater resulting from the RCRA unit. In December 1995, RVAAP began to filter the groundwater samples prior to analysis. The metals results from the 4th quarter of 1995 and subsequent results have been for dissolved metals. All preceding results were for total metals. Turbidity values ranged from <1.00 (ND) to 1300 NTU between 4/92 and 6/96, with no noticeable decrease in turbidity in the quarters since December 1995. Monitoring wells were installed on the north, south, east, and west perimeters of the OBG at Pad #37 in 1992. The four wells were installed for the purpose of detection monitoring of the RCRA unit, and have been sampled 15 times since 1992 (USAEHA 1992). The Phase II RI data from these monitoring wells are included in this RI Report, discussed in Section 4, and included in Appendix F.

All four monitoring wells encountered mixtures of clay and silt with an occasional interbedded sand layer. The wells were completed and screened in unconsolidated material at the top of bedrock, a weathered shale and sandstone. Well depths range from 5.97 to 7.23 m (19 to 23 ft) bgs. OBG-1 is considered the upgradient well. Groundwater flows from west to east, according to the most recent water level measurements (1998).

Groundwater at the OBG has exhibited minor concentrations of RDX and TNB in the upgradient well as well as in the downgradient wells, but these occurrences have been intermittent. Some metals, such as selenium and arsenic, have been present above the MCLs for drinking water in more than one sampling round, but their occurrences have not followed any trend or pattern.

The source of any groundwater contamination at the OBG—contamination in the soils—is likely to be of the same character as that found throughout WBG. Because WBG is being evaluated under CERCLA, the USACE, OEPA, and RVAAP have agreed to defer the cleanup of soil contamination at the OBG to the CERCLA program. Any groundwater contamination at OBG is likely the result of burning that took place on the soils at OBG, rather than on the burning trays. Therefore, groundwater cleanup for the purposes of closure of the RCRA unit at OBG is also deferred to the CERCLA process.

2.3 METEOROLOGICAL INVESTIGATIONS

No meteorological investigations were conducted as part of the Phase II RI at WBG.

2.4 PHASE II RI FIELD INVESTIGATION

The field investigations conducted for the Phase II RI at WBG and the facility-wide background investigation included sampling of surface and subsurface soils; installation, testing, and sampling of monitoring wells; and sampling of surface water and sediment. Individual WBG sampling locations were based on information collected during the Phase I RI and other previous investigations. Background sampling locations were selected on the basis of the glacial and bedrock geology of the eastern half of the RVAAP installation and the locations of native or upgradient areas within the installation boundaries (see Section 3.0), and in concurrence with representatives of the OEPA and the USACE. The following sections describe the rationales for and methods of sample collection during the Phase II RI.

2.4.1 Surface Soil

Surface soil samples [0 to 0.3 m (0 to 1 ft)] were collected at 14 facility-wide background locations and the 14 burning pads and the Deactivation Furnace Area, respectively, to evaluate naturally occurring conditions and potential releases of contaminants in soils at WBG. Surface soil sample locations at WBG are illustrated

in **Figure 2-1**. Facility-wide background locations are shown in **Figure 2-2**. All soil samples collected are documented in soil boring logs presented in Appendix A.

The results of the Phase I RI at WBG indicated that the release of explosive residues, heavy metals, and other chemicals onto surface soils occurred at several of the burning pads at WBG. Surface water runoff from these pads may have conveyed these materials overland to adjacent soils and drainage ditches that traverse the WBG.

2.4.1.1 Rationale

The Phase II RI objectives for the surface soil sampling program were as follows:

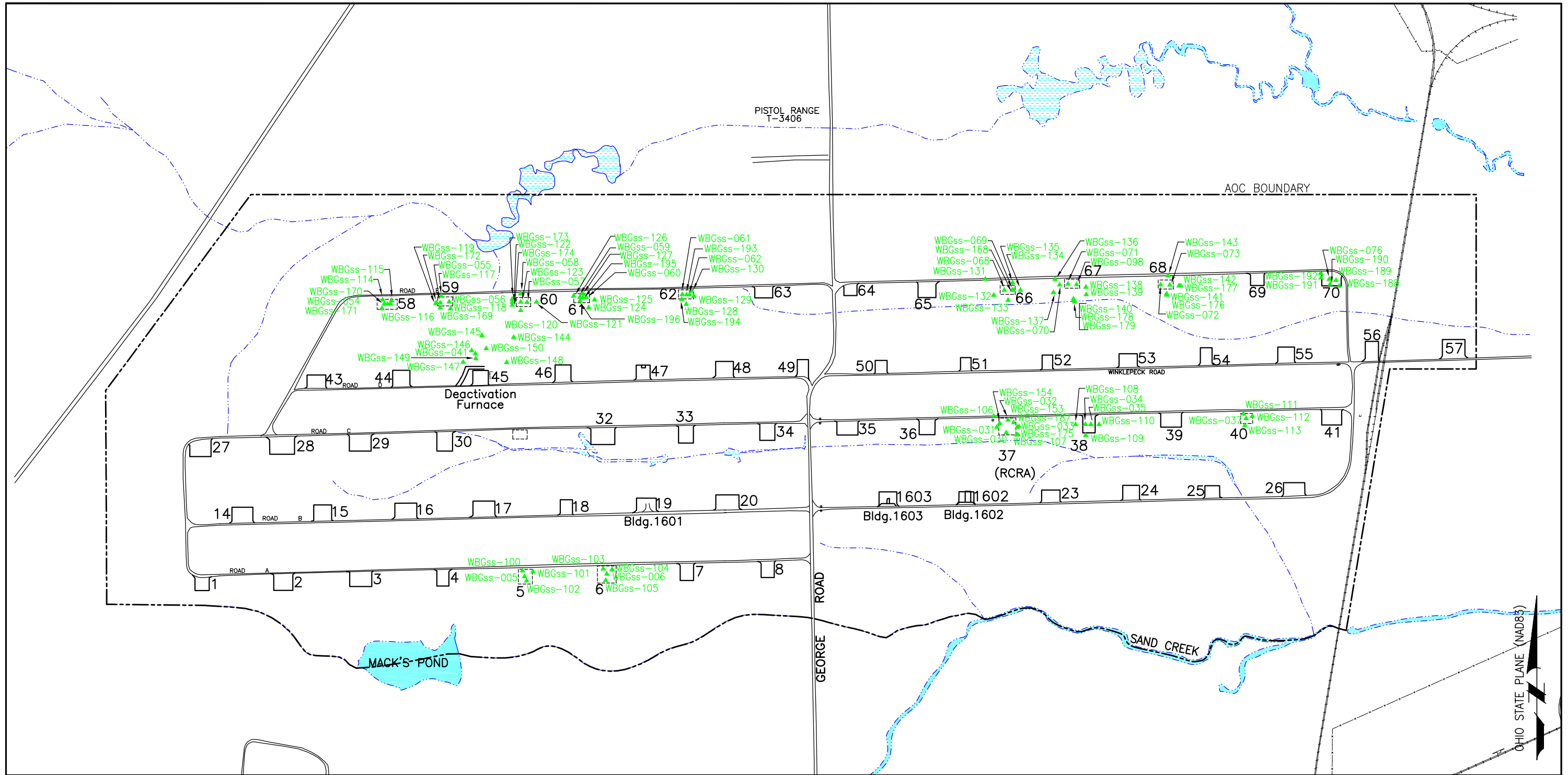
- Determine the nature and horizontal extent of contamination at the ground surface at each of the 14 former burning pads having either explosives in excess of 1 ppm or lead in excess of 100 ppm during the Phase I RI. The burning pads subject to further investigation based on the criteria stated above are Pads #5, 6, 37, 38, 40, 58, 59, 60, 61, 62, 66, 67, 68, and 70.
- Further characterize the extent of contamination in surface soils at the Deactivation Furnace Area (Pad #45).
- Develop a background data set that characterizes natural facility-wide variability in the 23 TAL metals by collecting additional background surface soil samples from 14 locations across the installation.

The rationale for this biased surface soil sampling strategy at WBG was to augment the Phase I and other previous data sets to fully characterize the burning pads that pose a threat to human health and the environment. Two to five Phase II RI surface soil samples were collected from each of the 14 pads for a total of 59 sample locations. The exact locations of the samples were finalized in the field based on observations (e.g., staining, vegetative stress, drainage, etc.). An additional 16 contingency samples were located at various pads after the first 59 samples were collected, based on field screening test results. These samples were used to delineate horizontal extent of contamination or to characterize visibly contaminated spots on the pads.

Included in the sampling strategy for soils at WBG and the background locations was the use of color spectrophotometry, or colorimetry, to analyze explosive compounds TNT and RDX in the field. All surface soil samples in both the WBG and background locations, and all WBG subsurface soils, were subject to analysis with the colorimetric method to determine whether explosives were present in the soils at concentrations greater than 1 ppm. The rationale for employing the field method was to delineate extent of explosives-contaminated “hot spots” on a “real time” basis and to select samples for fixed-base laboratory analysis to characterize the nature and extent of contamination present (see Section 2.5.1). Jenkins (1990) has shown that field colorimetric results for TNT can be, under proper conditions, as accurate and precise as the EPA SW-846 Method 8330 results (EPA 1990a). The RDX method is somewhat more subject to interferences (such as high humidity and the presence of humic substances in the soils).

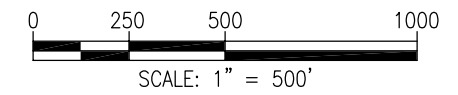
It should be noted that sample preparation methods for TNT and RDX will result in color development for explosives other than TNT or RDX that are typically found at RVAAP [e.g., DNT, tetryl, TNB, or dinitrobenzene (DNB) in the TNT method; HMX, propellants, or pentaerythritol tetranitrate (PETN) in the RDX method]. Because of these interferences, field colorimetric measurements are considered bulk values for TNT, RDX, and related compounds. As such, colorimetric data cannot be used in human health or ecological risk assessments because each concentration used to calculate risk must be for a single analyte. However, the data can be used in the field to refine the sampling strategy to help define extent of contamination. For example, a nondetect of explosives in surface soil at a given location indicates that:

- No TNT, RDX, or related explosives are present in the surface soil at this location. Therefore, any “hot spot” at a particular burn pad does not extend to the sample point.



LEGEND:

- 5 PAD LOCATION WITH ID
- APPROXIMATE LOCATION OF PAD
- ASPHALT ROAD
- RAILROAD TRACKS
- BEAVER DAM POND
- POND
- STREAM
- ▲ SURFACE SOIL SAMPLE LOCATION



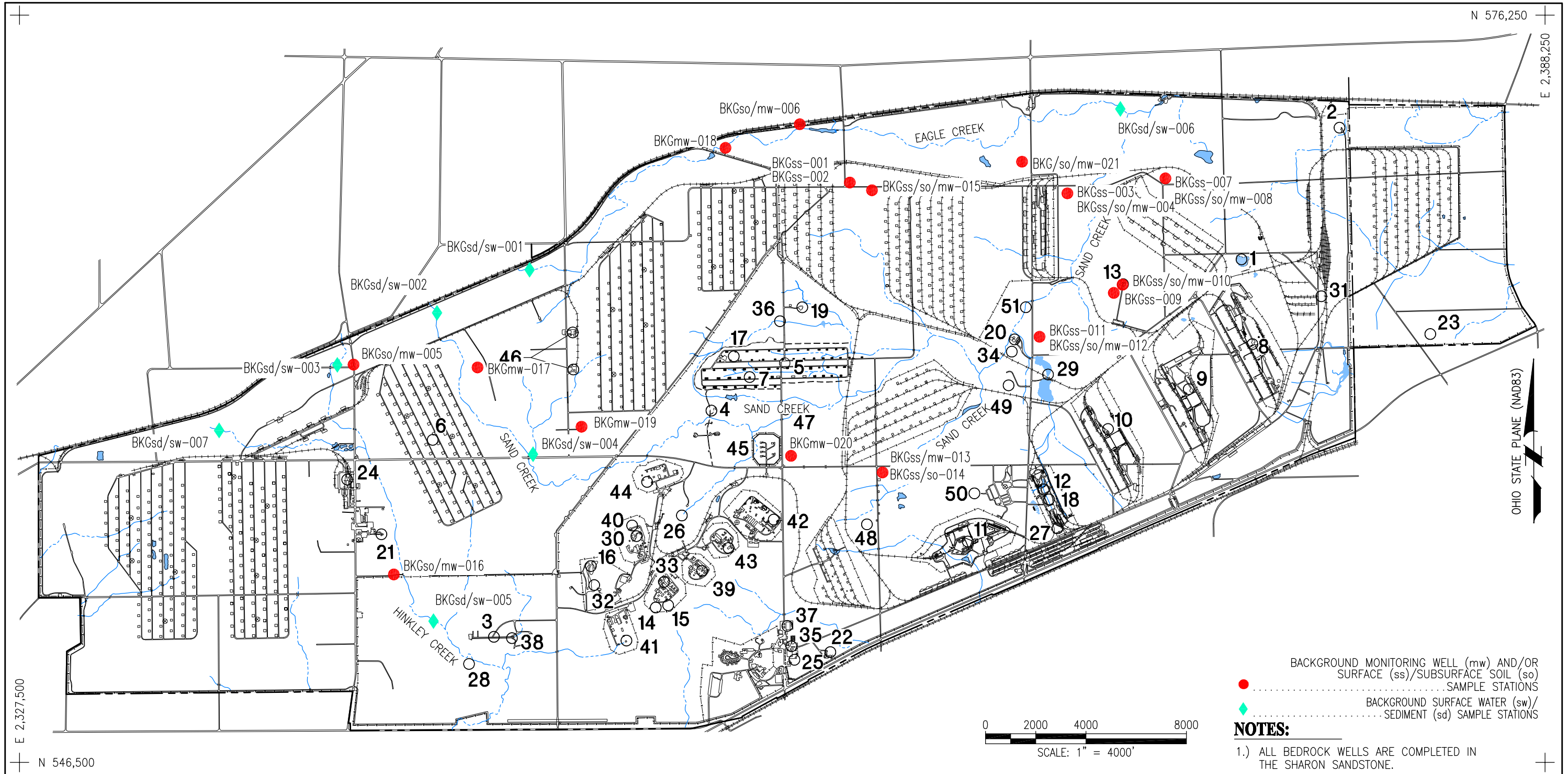
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US Army Corps of Engineers
Louisville District

**RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
WINKLEPECK BURNING GROUNDS**

DRAWN BY: P. HOLM	REV. NO./DATE: REV. 1/07-26-99	CAD FILE: 98026/DWGS/D23-SS
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Figure 2-1. WBG Surface Soil Sample Locations, Phase II RI



● BACKGROUND MONITORING WELL (mw) AND/OR SURFACE (ss)/SUBSURFACE SOIL (so) SAMPLE STATIONS
 ◆ BACKGROUND SURFACE WATER (sw)/SEDIMENT (sd) SAMPLE STATIONS

NOTES:
 1.) ALL BEDROCK WELLS ARE COMPLETED IN THE SHARON SANDSTONE.

LEGEND OF SITES:			
1	RAMSDALL QUARRY LANDFILL	13	BLDG 1200 AND DILUTION/SETTLING POND
2	ERIE BURNING GROUNDS	14	LOAD LINE 6, EVAPORATION UNIT
3	DEMOLITIONS AREA #1	15	LOAD LINE 6, TREATMENT PLANT
4	DEMOLITIONS AREA #2	16	QUARRY LANDFILL/FORMER FUZE & BOOSTER BURNING PITS
5	WINKLEPECK BURNING GROUNDS	17	DEACTIVATION FURNACE
6	C BLOCK QUARRY	18	LOAD LINE 12 PINK WASTE WATER TREATMENT
7	BLDG 1601 HAZARDOUS WASTE STORAGE	19	LANDFILL NORTH OF WINKLEPECK BURNING GROUND
8	LOAD LINE 1 AND DILUTION/SETTLING POND	20	SAND CREEK SEWAGE TREATMENT PLANT
9	LOAD LINE 2 AND DILUTION/SETTLING POND	21	DEPOT SEWAGE TREATMENT PLANT
10	LOAD LINE 3 AND DILUTION/SETTLING POND	22	GEORGE ROAD SEWAGE TREATMENT PLANT
11	LOAD LINE 4 AND DILUTION/SETTLING POND	23	UNIT TRAINING SITE WASTE OIL TANK
12	LOAD LINE 12 AND DILUTION/SETTLING POND	24	RESERVE UNIT MAINTENANCE AREA WASTE OIL TANK
13	BLDG 1034 MOTOR POOL WASTE OIL TANK	25	BLDG 1034 MOTOR POOL WASTE OIL TANK
14	LOAD LINE 6, EVAPORATION UNIT	26	FUZE BOOSTER AREA SETTLING TANKS
15	LOAD LINE 6, TREATMENT PLANT	27	BLDG 854-PCB STORAGE
16	QUARRY LANDFILL/FORMER FUZE & BOOSTER BURNING PITS	28	MUSTARD AGENT BURIAL SITE
17	DEACTIVATION FURNACE	29	UPPER AND LOWER COBBS POND COMPLEX
18	LOAD LINE 12 PINK WASTE WATER TREATMENT	30	LOAD LINE 7 PINK WASTEWATER TREATMENT PLANT
19	LANDFILL NORTH OF WINKLEPECK BURNING GROUND	31	ORE PILE RETENTION POND
20	SAND CREEK SEWAGE TREATMENT PLANT	32	40 AND 60 MM FIRING RANGE
21	DEPOT SEWAGE TREATMENT PLANT	33	FIRESTONE TEST FACILITY
22	GEORGE ROAD SEWAGE TREATMENT PLANT	34	SAND CREEK DISPOSAL ROAD LANDFILL
23	UNIT TRAINING SITE WASTE OIL TANK	35	1037 BUILDING-LAUNDRY WASTEWATER SUMP
24	RESERVE UNIT MAINTENANCE AREA WASTE OIL TANK	36	PISTOL RANGE
25	BLDG 1034 MOTOR POOL WASTE OIL TANK	37	PESTICIDE STORAGE BUILDING T-4452
26	FUZE BOOSTER AREA SETTLING TANKS	38	NACA TEST AREA
27	BLDG 854-PCB STORAGE	39	LOAD LINE 5 / FUZE LINE 1
28	MUSTARD AGENT BURIAL SITE	40	LOAD LINE 7 / BOOSTER LINE 1
29	UPPER AND LOWER COBBS POND COMPLEX	41	LOAD LINE 8 / BOOSTER LINE 2
30	LOAD LINE 7 PINK WASTEWATER TREATMENT PLANT	42	LOAD LINE 9 / DETONATOR LINE
31	ORE PILE RETENTION POND	43	LOAD LINE 10 / PERCUSSION ELEMENT
32	40 AND 60 MM FIRING RANGE	44	LOAD LINE 11 / ARTILLERY PRIMER
33	FIRESTONE TEST FACILITY	45	WET STORAGE AREA
34	SAND CREEK DISPOSAL ROAD LANDFILL	46	BUILDING'S F-15 AND F-16
35	1037 BUILDING-LAUNDRY WASTEWATER SUMP	47	BUILDING T-5301 DECONTAMINATION
36	PISTOL RANGE	48	ANCHOR TEST AREA
37	PESTICIDE STORAGE BUILDING T-4452	49	CENTRAL BURN PITS
38	NACA TEST AREA	50	ATLAS SCRAP YARD
39	LOAD LINE 5 / FUZE LINE 1	51	DUMP ALONG PARIS-WINDHAM ROAD

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 Louisville District
LOUISVILLE, KENTUCKY

RAVENNA ARMY AMMUNITION PLANT
 RAVENNA, OHIO
WINKLEPECK BURNING GROUNDS

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Figure 2-2. RVAAP Phase II RI Facility-wide Background Sampling Locations

- It is unlikely that explosives are present in the subsurface given the surficial nature of the releases (unless the soil has been reworked); therefore, no subsurface sampling is proposed to define the vertical extent of contamination.

Procedures for measuring TNT and RDX in soils using field colorimetry are described in Section 2.5.1.

All surface soil samples collected at WBG during the Phase II RI were analyzed for TAL metals and cyanide. SVOCs were analyzed in four randomly selected surface soil samples. On the basis of the field colorimetric results for TNT and RDX, all samples with detectable levels of these compounds in the field method were sent to the fixed-base laboratory for explosives and propellant analysis. Triple-based propellants (nitrocellulose, nitroglycerine, and nitroguanidine) were not scoped in the SAP. Analyses of these compounds were added in the field for 28 samples that had field-screening detections of explosives. Because the capacity for sample analyses was fixed, some samples could not be analyzed for nitrocellulose. In addition, 15 percent of the field explosive nondetects (roughly one from each pad) were also sent to the fixed-base laboratory for confirmatory explosives analysis. The field and fixed-base analytical results for surface soil samples are presented in Appendix F of this report.

2.4.1.2 Field Sampling Methods

All surface soil samples collected during the Phase II RI at WBG and the background locations were composites resulting from the mixture of three subsamples, collected in a triangular array with 0.9 m (3 ft) between samples. Chemical data have shown that the explosives in common use at RVAAP have low mobility in soils and are distributed as solid, bulk material. Disposal of outdated or off-specification materials by open burning has caused a variable dispersal of explosives across the ground surface. Concentrations may range from nondetectable to the percent range in samples collected a few inches or feet apart. Solid pieces of TNT or other bulk explosives are commonly present in surface soils. Because of these occurrences of explosive compounds in soils, sampling errors may result from collection of single, discrete surface soil samples. Composite sampling has been shown to reduce statistical sampling errors in surface soil data at sites with a history of explosives contamination in surface soils (Jenkins et al. 1996). That is, the likelihood of capturing detectable levels of explosives in soils over an area the size of a burn pad is greater with composite sampling than with discrete sampling. Composite sampling data for explosives analysis are considered acceptable to EPA for use in risk assessments (EPA 1996a) where concentrations are expected to vary spatially.

WBG

Surface soil samples were collected from the 0- to 0.3-m (0- to 1-ft) interval. Each surface soil sample was composited from three subsamples collected from a 0.9- × 0.9-m (3- × 3-ft) area in a roughly equilateral triangle pattern. Sampling was accomplished using hand augers with a 7.62-cm (3-in.) bucket or a stainless steel spoon or scoop. Material collected in the auger bucket during augering of each interval was removed using a stainless-steel spoon. Equal portions of soil from the subsamples were composited and homogenized in a stainless steel bowl. After the samples were homogenized and split, a portion was analyzed with field colorimetry methods described below. If the sample tested positive for either TNT or RDX in the field colorimetric analyses, a portion of the sample was sent for laboratory analysis.

During sample collection, all samples were field screened for volatile organic compounds (VOCs) using a hand-held photoionization detector or flame ionization detector organic vapor analyzer. No headspace samples were collected for organic vapor monitoring.

Following collection of the sample, the surface soil lithologies and/or general soil characteristics were recorded in the project logbooks. After completion, each borehole was staked with a 0.6-m (2-ft) rebar stake and labeled and the location recorded in relation to a reference monument, for which Ohio State plane

coordinates have been determined. Excess soil from the borehole was placed in lined, labeled 242-L (50-gal) drums that were sealed after each use and staged at WBG. Investigation-derived waste practices for all media are discussed in Appendix I.

Background

Surface soil samples were collected at 15 locations on the eastern half of RVAAP. Originally the sample locations were intended to correspond with the seven background monitoring well pairs proposed in the SAP Addendum. These locations were chosen with the concurrence of OEPA and the USACE to reflect areas not impacted by RVAAP activities and to establish background values that are unaffected by any human activity. The background locations are situated upgradient and generally upwind of known or suspected contaminant sources.

Surface soil samples BKGss-001 through -015 were collected at the locations shown in **Figure 2-2**. However, after these samples were submitted for laboratory analysis, it was learned that the subsurface geological conditions were not favorable for installation of both a deep and shallow well at several locations. Monitoring well locations had to be modified in the field, but no background surface soil samples were collected at the new locations BKGmw-016 through -021. These changes to the sampling program were reviewed with OEPA in the field.

The background surface soil samples were collected and analyzed in the same manner as the surface soil samples at WBG. Soils were collected using a hand auger, and composited from three subsamples collected in a 0.9-m (3-ft) triangle. A portion of the homogenized sample was analyzed for explosives in the field colorimetry laboratory. If the results of the TNT or RDX evaluations were positive, another background sampling location was chosen. If the results were negative, a portion of the homogenized sample was sent to the off-site laboratory for characterization.

All background surface soil samples were analyzed for TAL metals, cyanide, and SVOCs. Two of the background samples were additionally analyzed for VOCs and pesticides/PCBs. The field and fixed-base laboratory analytical results for the background samples are provided in Appendix F.

2.4.2 Subsurface Soils

2.4.2.1 Rationale

The collection of subsurface soils at WBG was designed to define the vertical extent of contamination resulting from surficial burning of explosives and to evaluate migration pathways of any such contamination. At the background locations, the rationale of subsurface sampling was to determine naturally occurring concentrations of several constituents, including TAL metals by depth. More specifically, the intent was to determine if naturally occurring concentrations of these analytes vary among permeable and impermeable lithologies.

WBG

One sample was initially collected at each of the 14 pads, at a depth of 0.2 to 1.2 m (2 to 4 ft), to evaluate the vertical extent of contamination. This sample was selected at the location of the surface soil sample with the highest concentrations of explosives as determined from Phase I RI analytical results or Phase II field colorimetric data. The rationale for this approach to sampling was that, if contamination could not be identified in the shallow subsurface immediately below the most contaminated surface locations, it was not likely to be present elsewhere. Other subsurface samples were collected based upon field colorimetry results elsewhere on each pad to determine vertical extent. For example, if the 0.6- to 1.2-m (2- to 4-ft) sample tested negative (<1 ppm) for explosives via the field method, no deeper sampling was performed. The rationale for

this decision is that, if contamination is not evident in the shallow subsurface, its presence in the deeper interval is unlikely. However, if the sample tested positive (> 1 ppm) for explosives via the field method, the 1.2- to 1.8-m (4- to 6-ft) interval in the same location was also sampled.

Soils below 1.8 m (6 ft) were not sampled because of the shallow occurrence of the local water table at WBG. Unlike the surface soil samples, all subsurface soil samples were analyzed by the fixed-base laboratory for explosives, metals, SVOCs, VOCs, and cyanide regardless of field colorimetric results. Subsurface soil sampling locations are illustrated in **Figure 2-3**.

Background

Continuous subsurface soil samples were collected from each of the background groundwater monitoring well borings (BKGmw-004, -005, -006, -008, -010, -012, -014, -015, -016, -017, -018, -019, -020, and -021) during drilling. Wells were completed in either unconsolidated material (sand or silt) or bedrock (sandstone or shale) with the intent to collect samples from both impervious and pervious lithologies. Samples were collected from the 0.3- to 0.9-m (1- to 3-ft) interval, and from within the 0.9- to 3.6-m (3- to 12-ft) interval. Discrete, representative samples from both intervals in every boring were analyzed for TAL metals, SVOCs, and cyanide, in addition to being field screened for explosives TNT and RDX. Two discrete, representative samples (one from each interval) were additionally analyzed for VOCs to ensure the integrity of the background locations.

2.4.2.2 Field Sampling Methods

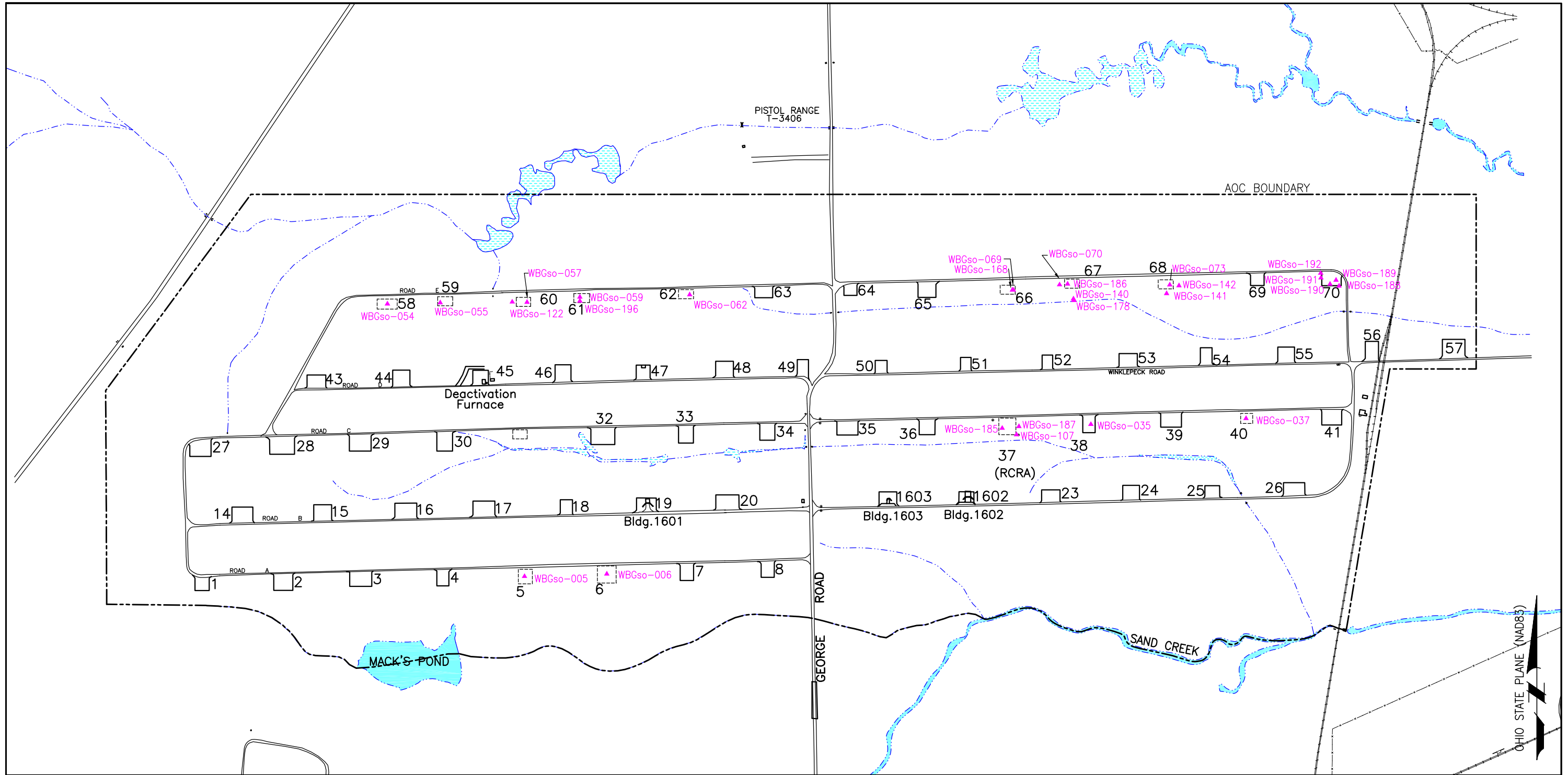
WBG

No horizontal composite sampling of subsurface intervals was attempted. One discrete soil sample was collected from each depth interval at each burning pad, at locations where surface soil samples exhibited evidence of explosives contamination [i.e., TNT and/or RDX at greater than 1 ppm by field screening (colorimetric) methods]. Samples were collected using hand-operated power augers and bucket hand augers and homogenized over the depth interval, except for VOC samples, which were collected from the middle of each interval without mixing.

As described in Section 2.4.1, surface soil samples [0 to 0.6 m (0 to 1 ft)] were sampled using the bucket hand auger and submitted for colorimetric field screening for TNT and RDX. If colorimetric analyses were positive, i.e., greater than 1 ppm for either explosive, the 0.6- to 1.2-m (2- to 4-ft) intervals were sampled. Thirteen samples were collected from this depth interval. These samples were then analyzed in the field using the colorimetric method, and if TNT or RDX were detected at concentrations >1 ppm, the 1.2- to 1.8-m (4- to 6-ft) interval was then sampled. This was accomplished by using the hand-operated power auger to overdrill the 0- to 0.3-m (0- to 1-ft) interval and advance the boring to 0.6 m (2 ft) bgs. The power auger flights, 15.2 cm (6 in.) in diameter, were attached to and rotated by a gasoline-powered hydraulic drive. By increasing the diameter of the borehole in the 0- to 0.6-m (0- to 2-ft) interval, the bucket hand auger was more easily advanced to the target depth. Where subsurface conditions permitted, the hand auger was used to complete the boring without the use of the power auger. In some sampling locations, refusal of either the hand or power auger prevented reaching the target sampling depth. In such cases, samples were collected from the deepest subsurface interval achieved.

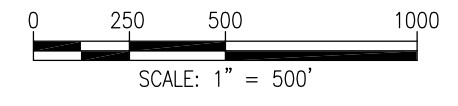
The soil samples were collected from each interval by mixing in a stainless steel bowl before filling sampling containers. Material collected in the auger bucket was removed using a stainless steel spoon.

Organic vapors were monitored in the subsurface soil boring using field instruments. No headspace samples were collected. Breathing zone gas concentrations were recorded in the project logbooks.



LEGEND:

- 5 PAD LOCATION WITH ID
- 5 APPROXIMATE LOCATION OF PAD
- ASPHALT ROAD
- RAILROAD TRACKS
- POND
- BEAVER DAM POND
- STREAM
- ▲ SUBSURFACE SOIL SAMPLE LOCATION




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 Louisville, Kentucky

RAVENNA ARMY AMMUNITION PLANT
 RAVENNA, OHIO
WINKLEPECK BURNING GROUNDS

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Figure 2-3. WBG Subsurface Soil Sample Locations, Phase II RI

Following collection of the sample, the subsurface soil lithologies and/or general soil characteristics were recorded in the project logbooks. The borehole was plugged with bentonite and water and abandoned. Excess soil from the borehole was placed in lined, labeled 242-L (50-gal) drums that were sealed after each use and staged at WBG. Investigation-derived waste practices for all media are discussed in Appendix I.

Background

One discrete sample from each interval [0.3 to 0.9 m and 0.9 to 3.7 m (1 to 3 ft and 3 to 12 ft) bgs] was selected for analytical testing from each soil boring. Samples were collected using 3-in. diameter, 2-ft length split spoon samplers in conjunction with the hollow-stem drilling method, or from continuous samplers advanced by the Rotasonic drilling method. Sample intervals were selected in an attempt to provide samples from all representative lithologies encountered. Special emphasis was given to collecting samples representing permeable and impermeable lithologies. Subsurface soil samples were analyzed for explosives and TAL metals. Background soil borings were converted to background groundwater monitoring wells.

2.4.3 Sediment and Surface Water Sampling

2.4.3.1 Rationale

WBG

Runoff from contaminated burn pads may contribute contaminants in dissolved and suspended form to the surface water system at WBG, which is unlined and untreated. Sediment and surface water sampling took place in Mack's Pond to evaluate the surface water migration pathway. Sediment samples were also collected at the outlet of Mack's Pond and in two small drainages that exit the AOC on its eastern boundary (**Figure 2-4**). These four locations, which represent all the major surface water transport pathways, were selected to evaluate whether the drainages at WBG allow contaminants to migrate eastward beyond the AOC boundary.

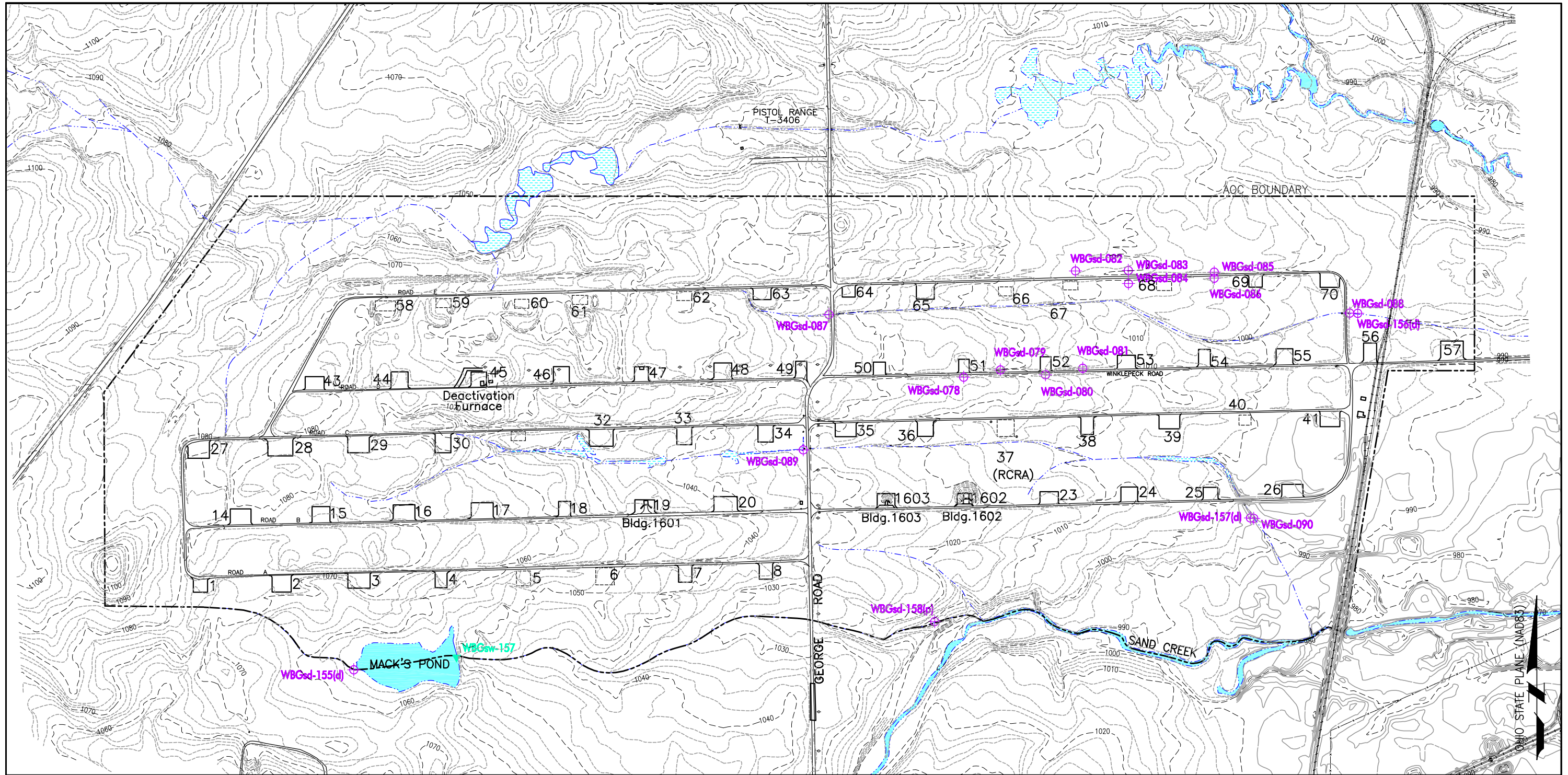
Background

Background surface water and sediment conditions were not determined in the Phase I RI, and are necessary for an evaluation of risk in these environmental media. Seven locations for the sampling of sediment and surface water representative of background conditions were chosen along Hinkley, Sand, and Eagle Creeks (see **Figure 2-2**). The locations were selected in areas believed to not have been impacted by activities at RVAAP. These locations are upgradient of surface water runoff and process effluent discharge associated with past process operations at RVAAP, as well as upwind of the major load lines. There are no known or suspected sources of contamination immediately upstream from the background sample locations. Two samples were collected from each of the three main creeks, with one additional sample on the extreme upstream end of the west tributary to Hinkley Creek. The background samples were collected and analyzed in the same manner as the ditch samples at WBG.

2.4.3.2 Field Sampling Methods

WBG and Background

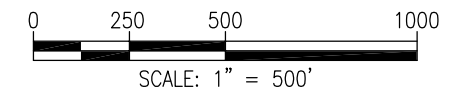
Surface water samples were collected first at each location, beginning with the furthest downstream point and moving upstream, to minimize the effects of sediment turbidity on water quality. All surface water was collected as described in Section 4.6.2.1.1 of the *Facility-Wide SAP for RVAAP* (USACE 1996a). Hand-held bottles were used to sample water in the streams. Each container was submerged into the water, with the cap in place. Then the container was allowed to slowly, continuously fill. Water quality measurements (pH, conductivity, dissolved oxygen content, and temperature) were recorded during sample collection. Background surface



LEGEND:

- 5 PAD LOCATION WITH ID
- APPROXIMATE LOCATION OF PAD
- ASPHALT ROAD
- RAILROAD TRACKS
- POND
- BEAVER DAM POND
- STREAM
- 10 FT. CONTOUR INTERVAL (AMSL)
- 2 FT. CONTOUR INTERVAL (AMSL)

▼ WBGsw-157 ... SURFACE WATER SAMPLE LOCATION
⊕ WBGsd-155(d) ... SEDIMENT SAMPLE LOCATION



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Figure 2-4. WBG Surface Water and Sediment Sampling Locations

water samples were not filtered, and were analyzed for TAL metals and cyanide. Both filtered and unfiltered samples were collected from Mack's Pond and were analyzed for TAL metals. Cyanide, VOCs, SVOCs, and explosives analysis was performed on unfiltered samples. Analytical results from the surface water samples are presented in Appendix F.

All sediment samples were collected from 0 to 0.015 m (0 to 0.5 ft) below the sediment-water interface, from areas of the stream channels where surface water was pooled or ponded. Samples were collected using either a bucket hand auger, in the case of dry sediments, or a stainless steel scoop or trowel, as described in Section 4.3.2 of the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Grounds and Determination of Facility-Wide Background at RVAAP* (USACE 1998a). The sediments were homogenized from three subsamples collected about 0.9 m (3 ft) apart from one another in a triangle. Equal portions of the sediment from the subsamples were homogenized in a stainless steel bowl. Sediment samples from WBG were homogenized and submitted to the field colorimetry laboratory for analysis of TNT and RDX. The drainage ditch samples were also analyzed for explosives, TAL metals, and cyanide, while the sample from Mack's Pond additionally received analyses for VOCs and SVOCs. Background samples that tested positive for field explosives were rejected, and a new background sample location was chosen. All background samples were submitted to the fixed-base laboratory for analysis of explosives, TAL metals, SVOCs, and cyanide; three of the seven samples received additional analyses of VOCs and pesticides/PCBs. All analytical results for WBG and background sediments are presented in Appendix F.

2.4.4 Groundwater Sampling

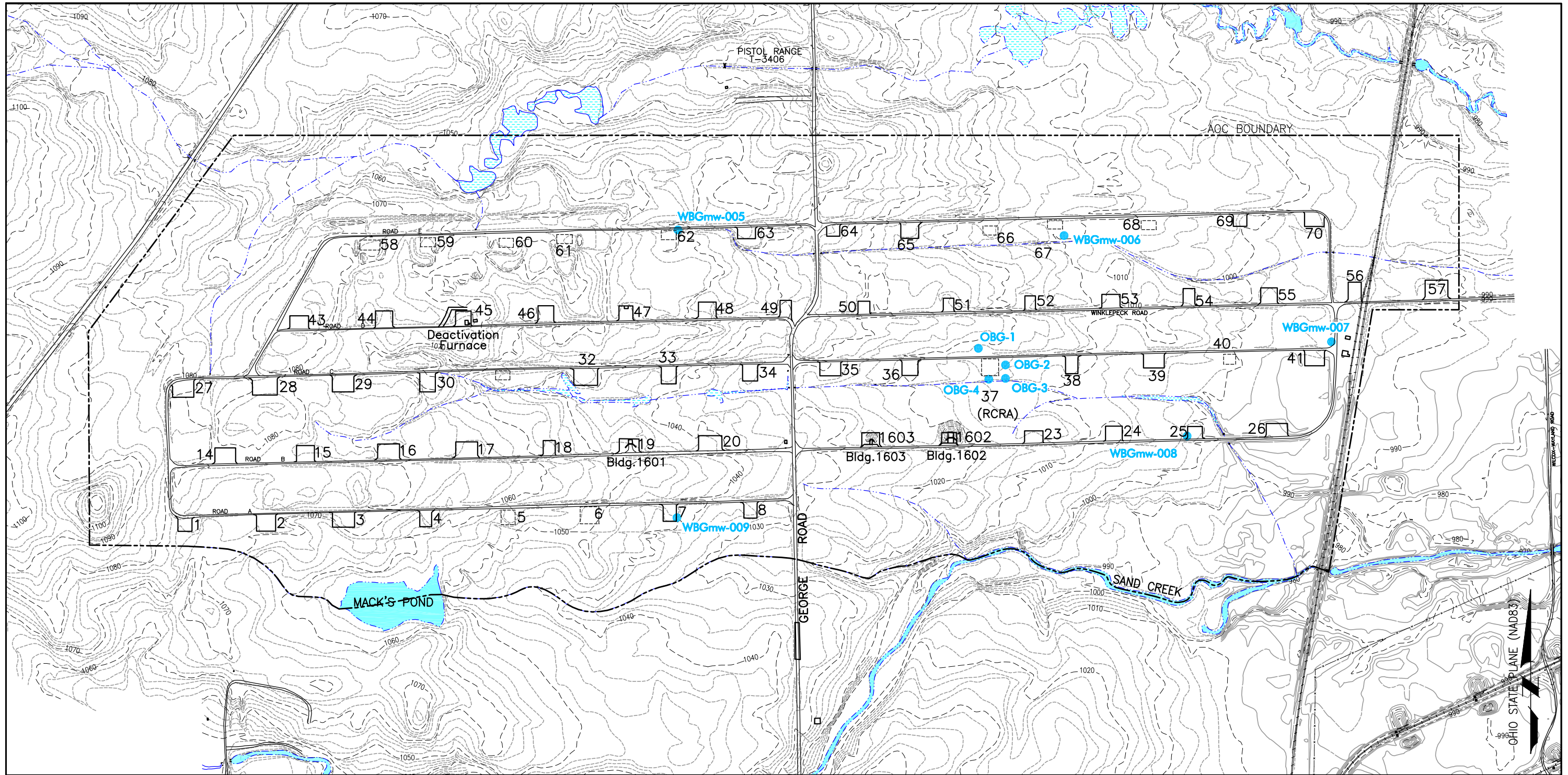
2.4.4.1 Rationale

WBG

Five monitoring wells were installed in the shallow water table zone at WBG during the Phase II RI. These monitoring wells were located in the suspected upgradient and downgradient directions from the most concentrated areas of soil contamination identified in Phase I and other investigations, in the northeastern quadrant of the WBG (**Figure 2-5**). One well (WBGmw-006) is located near the burning pad identified in Phase I as having the highest concentrations of explosives and metals in soils, in order to determine groundwater quality adjacent to a potential source of contaminant release. The five wells provide data on the WBG flow system and chemical groundwater quality, and augment the information acquired through the quarterly monitoring of four previously installed RCRA monitoring wells at the OBG. Characterization of the groundwater regime at WBG also included the sampling of four previously installed wells at Pad #37 (see Section 1.0).

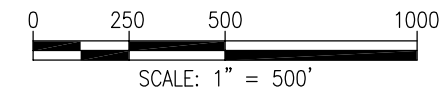
Background

Fourteen monitoring wells were installed throughout RVAAP in areas believed to be unaffected by facility operations with the concurrence of the OEPA (see **Figure 2-2**). Seven monitoring wells were completed in the unconsolidated, unconfined water table unit. Seven wells were completed in bedrock of the Sharon Member of the Pennsylvanian Pottsville Formation. This placement of the wells allows an evaluation of regional flow and chemical quality in both the shallow unconsolidated and deeper bedrock-saturated zones that underlie RVAAP. In addition, the placement of the bedrock monitoring wells offers an opportunity to expand the limited knowledge currently available on the subsurface geology at RVAAP. It was originally proposed that the background monitoring wells be paired at seven locations on the eastern half of the installation. However, when drilling began, it was discovered that some of the proposed locations were underlain by Hiram Till deposits greater than 15.7-m (50-ft) thick, making them undesirable drilling locations for bedrock monitoring wells. This was the case at BKGmw-013 and BKGmw-004. Similarly, there was insufficient glacial cover to install shallow, unconsolidated zone, monitoring wells beside the bedrock wells BKGmw-006, -008, -010, -012, and -015. As a result, four of the unconsolidated zone monitoring wells (BKGmw-005, -016, -017, and -019)



LEGEND:

- 5 PAD LOCATION WITH ID
- APPROXIMATE LOCATION OF PAD
- ASPHALT ROAD
- RAILROAD TRACKS
- POND
- BEAVER DAM POND
- 10 FT. CONTOUR INTERVAL (AMSL)
- 2 FT. CONTOUR INTERVAL (AMSL)
- WBGMw-006 MONITORING WELL
- STREAM



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Figure 2-5. WBG Monitoring Well Locations

were relocated to upgradient or native areas on the western half of the installation. Wells BKGmw-005 and BKGmw-016 are placed in the Lavery Till; whereas the remaining wells are in the Hiram Till assemblage.

2.4.4.2 Monitoring Well Installation, Development, and Sampling

All monitoring well installation, development, and sampling were conducted according to the *Facility-Wide SAP for RVAAP*, and the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Grounds and Determination of Facility-Wide Background at RVAAP* (USACE 1996a, 1998a).

Monitoring wells were installed using hollow-stem auger, air-rotary, and rotasonic drilling methods under the direct supervision of a qualified geologist. A 16.5-cm (6-in.) inside diameter, hollow-stem auger was used to advance the borehole through unconsolidated materials. Soil samples were collected continuously from the surface to bedrock refusal or planned borehole termination depth using a split-barrel sampler or rotasonic core. Soil sampling was conducted at WBG for lithologic evaluation only. In the background borings, soil samples were collected for chemical analysis from 0.3 to 0.9 m (1 to 3 ft) and 0.9 to 3.8 m (3 to 12 ft), with the remainder of samples collected for lithologic logging. Where bedrock was encountered before the target depth was reached, the bedrock interval was cored with an NQ-sized [approximately 10 cm (4 in.)] bit using sonic or rotary drilling methods. Cores were used to determine lithologies and degree of weathering and fracturing in bedrock. The cored interval was then overdrilled using an air-rotary system with a 15.8-cm (6.25-in.) tricone roller bit, to achieve a sufficient borehole diameter for the installation of a monitoring well. A borehole log, including lithologic information, was recorded for each monitoring well boring. The monitoring well boring logs are provided in Appendix A.

Organic vapors were monitored from soil and rock cuttings at each borehole using field instruments. In addition, the breathing zone was continuously monitored for evidence of organic chemicals. All readings were recorded in the project logbooks. All of these measurements were transient or below safety thresholds. Generally, they could not be correlated to laboratory occurrences of organic compounds in soils (see Section 4.0 for discussion).

Following drilling of monitoring well boreholes to the appropriate depths, monitoring wells were constructed from pre-cleaned 5.0-cm (2.0-in.) schedule 40 polyvinyl chloride pipe. Well screens were commercially fabricated with slot widths of 0.125 cm (0.05 in.) or 0.025 cm (0.01 in.). Because it could not be determined exactly at what depth the water was coming from, monitoring wells BKGmw-012 and BKGmw-015 were constructed with 6-m (20-ft) screens, but all other monitoring wells were constructed using 3-m (10-ft) screens. For wells completed in unconsolidated material, the well casing and screen were assembled and lowered through the drill stem augers into the borehole for completion. Unconsolidated zone well screens were set to straddle the top of the water table static level. Where wells were completed in bedrock, the well casing and screen were assembled and lowered into the open borehole. Bedrock zone well screens were set with the top of the screen approximately 0.9 m (3 ft) into bedrock to monitor the upper bedrock interval. Following placement of the well casing and screen, a pre-washed filter pack, consisting of Global Supply No. 7 sand was tremied in place from the bottom of the borehole to approximately 0.6 m (2 ft) above the top of the well screen in each well. A 0.6-m (2-ft) or 0.9-m (3-ft) bentonite pellet annular seal was then poured into the borehole on top of the filter pack. A grout mixture consisting of Type I Portland cement and 5 percent bentonite was then tremied from the top of the annular seal to the ground surface, followed by the placement of a protective steel surface casing and construction of a mortar collar and cement pad. Three steel posts were installed around each well, painted, and labeled. Monitoring well installation procedures are provided in Section 4.3.2 of the *Facility-Wide SAP for RVAAP* (USACE 1996a). Construction diagrams are provided in Appendix B.

At least 48 hours after completion, each monitoring well was developed so that representative groundwater samples could be collected. Well development was accomplished by purging at least five well volumes of

groundwater, using a submersible pump or a bailer, until the development water was visually clear and sediment thickness in the well were less than 3.0 cm (0.1 ft). Well development records are included in Appendix B. Well construction diagrams, also included in Appendix B, summarize the construction details for the monitoring wells installed during the Phase II RI at WBG, including depths, screened intervals, and groundwater elevations.

Following well development, groundwater samples were collected at the monitoring wells installed during the Phase II RI, and at the four RCRA monitoring wells at the OBG. The procedure for sampling of groundwater is described in Sections 4.3.4 and 4.3.5 of the *Facility-Wide SAP for RVAAP* (USACE 1996a). Before sampling, the monitoring wells were purged until readings of pH, conductivity, and water temperature reached equilibrium. Groundwater samples were collected using dedicated or disposable Teflon bailers.

All groundwater samples from WBG were analyzed for total and dissolved TAL metals (unfiltered and filtered), explosives, cyanide, VOCs, and SVOCs. Groundwater samples were analyzed for the propellants nitroglycerine, nitrocellulose, and nitroguanidine. Background groundwater samples were analyzed for TAL metals and cyanide; two of these samples were additionally analyzed for VOCs and SVOCs. Groundwater samples analyzed for dissolved metals were filtered immediately after sample collection using a negative-pressure filtration system with 0.45- μm pores.

2.4.4.3 In-Situ Permeability Testing

Slug tests were performed at the five WBG wells and 14 background monitoring wells to estimate the hydraulic conductivity of the geologic materials surrounding each well screen. Slug tests followed the provisions of the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Ground and Determination of Facility-Wide Background at RVAAP* (USACE 1998a). These analyses estimated horizontal hydraulic conductivities in the screened interval of each well. Rising-head tests were completed by removing a cylinder (slug) from the well and monitoring the return to pre-test static water level over time. The tests were performed after each well had fully recovered from groundwater sampling, using automated data collection software and a notebook computer. The slug was designed to displace 0.3 m (1 ft) of water. To begin the test, the slug was withdrawn quickly from the well, and water level measurements began at that moment. A pressure transducer and data logger were programmed to record measurements on a logarithmic time scale. Water levels were monitored for a period of six hours or until the well re-equilibrated to 90 percent of the pre-test level. The data were evaluated using the Bouwer and Rice (1976) method. The results of the slug tests performed in May 1998 are presented in Appendix B and discussed in Section 3.6. **Table 2-1** provides a summary of well installation and testing during the Phase II RI.

2.5 ANALYTICAL PROGRAM OVERVIEW

2.5.1 Field Laboratory Program

All soil and sediment samples were field analyzed with colorimetric methods for TNT and RDX. The purpose of the analysis was to define the extent of soil contamination with respect to these explosive compounds. Field colorimetry was also used as a screening method to select soil samples for fixed-based confirmatory analysis to characterize the nature and extent of contamination and to reduce the number of samples that required fixed-base laboratory analysis for explosives. The strategy can be summarized as follows:

- If the field method indicated TNT was present at > 1 ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.

Table 2-1. Summary of WBG Phase II RI Well Construction Data

Well ID	Total Depth (ft bgs)	Elevation (GL)	Elevation (TOC)	Screened Interval (ft below TOC)	Lithology in Screened Interval	Hydraulic Conductivity (cm/s)
BKGmw004	19.5	965.160	967.660	11.6 – 21.6	Medium-grained sand	^a
BKGmw005	19.0	1149.443	1151.943	10.7 – 20.7	Medium-grained sand	2.79×10^{-3}
BKGmw006	35.1	1026.380	1028.880	27.2 – 37.2	Well sorted sandstone	6.64×10^{-4}
BKGmw008	25.0	970.397	972.897	17.2 – 27.7	Poorly sorted sandstone	6.45×10^{-4}
BKGmw010	22.0	1006.293	1008.793	11.4 – 21.4	Interbedded sandstone/shale	5.04×10^{-3}
BKGmw012	59.8	997.574	1000.074	42.1 – 52.1	Shale	3.32×10^{-5}
BKGmw013	25.5	986.59	989.09	17.7 – 27.7	Sand-gravel-silt	1.65×10^{-3}
BKGmw015	51.0	1037.897	1040.397	32.6 – 52.6	Shale	^a
BKGmw016	19.0	1098.419	1100.919	10.9 – 20.9	Sand and silt	1.26×10^{-3}
BKGmw017	34.8	1132.8	1135.3	25.7 – 35.8	Medium-grained sand and silt	^a
BKGmw018	24.7	1043.060	1045.560	17.0 – 27.0	Sandstone	2.56×10^{-3}
BKGmw019	34.0	1108.24	1110.74	25.5 – 35.5	Silty sand and gravel	^a
BKGmw020	30.7	1065.001	1067.501	23.0 – 33.0	Shale	^a
BKGmw021	19.0	972.159	974.659	10.2 – 20.3	Medium-grained sand	3.60×10^{-3}
WBGmw005	19.0	1052.198	1054.698	10.8 – 20.8	Clay with sand	3.89×10^{-5}
WBGmw006	19.0	1012.156	1014.656	10.1 – 20.1	Sandy silty clay	2.46×10^{-3}
WBGmw007	24.0	998.091	1000.591	15.9 – 25.0	Clay and sand	2.12×10^{-2}
WBGmw008	18.5	1005.709	1008.209	10.6 – 20.6	Sand	8.85×10^{-3}
WBGmw009	24.0	1045.029	1047.529	13.9 – 23.9	Silty sand	5.65×10^{-4}

^aHydraulic conductivity was not calculated for these wells because of data transmission errors during the test.

- If the concentration of TNT was < 1 ppm, the analysis for RDX was performed.
- If RDX was present at a concentration ≥ 1 ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.
- In addition, 15 percent of the samples showing non-detects of TNT or RDX were sent to the off-site laboratory for analysis of explosives.
- All samples collected, regardless of field colorimetry results, were submitted for TAL metals and cyanide analyses.

The procedure for measuring TNT concentrations in soils involves a liquid extraction of the explosives from the soil matrix with acetone, and formation of a color complex with sodium sulfite and potassium hydroxide. Absorbance is measured at a wavelength of 540 nm. For RDX, all nitrate must be removed from the extract, then glacial acetic acid and zinc powder are added. A color-producing agent is added to the sample, and absorbance is measured at 507 nm. In both methods, percent absorbance is correlated to concentration.

A full discussion of the field screening and laboratory results for TNT and RDX is presented in Appendix E of this report. Analyses of the field and laboratory data sets and duplicate pairs analyzed by the field methods revealed the following information.

The field screening values for TNT provided 14 percent false negative information and 23 percent false positive information. However, laboratory values for four of the field false negative responses were at levels less than 2 $\mu\text{g/g}$, while the other two false negative responses were at 2.8 $\mu\text{g/g}$ and 3.5 $\mu\text{g/g}$. The field method detection level was 1 $\mu\text{g/g}$, with an accuracy of ± 1 $\mu\text{g/g}$. Therefore the four laboratory values below 2 $\mu\text{g/g}$ would be an acceptable comparison to the field's detection limit of 1 $\mu\text{g/g}$ given the accuracy of the field method. This brings the field's percent false negative responses down to less than 5 percent.

Review of laboratory results for explosive compounds that, when present, may also contribute to color development (i.e., TNB, DNT, nitrotoluenes, nitrocellulose, etc.) indicates there were not any impacts on the field screening determinations from these compounds. Elevated levels of nitrocellulose (ranging from 88 to 315 $\mu\text{g/g}$ in some samples) did not appear to influence the TNT screening results. The low levels of other nitroaromatic compounds observed in these samples did not exhibit any impact on the TNT screening levels.

The limited TNT data available for comparison provide a correlation coefficient of 0.941. Field screening thus provided a valid representation of the presence or absence of TNT above 2 $\mu\text{g/g}$, and provided representative quantified results.

Two of the 45 field screening measurements for RDX indicating concentrations <1 $\mu\text{g/g}$ are considered false negative results (4 percent). In the same manner, two of the seven field screening measurements indicating concentrations >1 $\mu\text{g/g}$ are considered false positive results (29 percent). However, with the accuracy of the field method detection limit of ± 1 $\mu\text{g/g}$, one of the field false negative responses and one of the field false positive responses were at levels less than 2 $\mu\text{g/g}$ based on laboratory analysis. If concentrations within two times the method detection level (1 $\mu\text{g/g}$) are considered comparable, the false negative rate becomes 2 percent and the false positive rate becomes 14 percent.

Although there were only a limited number of duplicate pairs analyzed by the field screening operation, by the off-site laboratory, and between the field and laboratory, comparison of relative percent difference (RPD) results provides similar values as seen for TNT duplicate pairs.

Review of laboratory results for explosive compounds that, when present, may contribute to color development (i.e., HMX, nitrocellulose, nitroguanidine, etc.) does not indicate any obvious impacts on the field screening determinations from these compounds. Elevated levels of nitrocellulose (ranging from 88 to 315 $\mu\text{g/g}$ in some samples) did not appear to influence the RDX screening value. Low levels of HMX and nitroguanidine observed in these samples did not exhibit an impact on the RDX screening levels.

The limited RDX data available for comparison provide a correlation coefficient of 0.856. It is believed the field screening has provided a valid representation of the presence or absence of RDX above 2 $\mu\text{g/g}$; however, these few comparisons do not provide confidence in the field screening quantified results.

2.5.2 Laboratory Analysis

All analytical laboratory procedures were completed in accordance with applicable professional standards, EPA requirements, government regulations and guidelines, and specific project goals and requirements. All samples collected during the investigation were analyzed by Quanterra Laboratory, North Canton, Ohio, a USACE Center of Excellence (CX)-validated laboratory under contract for the investigation. Quality assurance (QA) samples were collected (soil, sediment, surface water, and groundwater), and analyzed by a USACE-CX laboratory located in Omaha, Nebraska. Laboratories supporting this work have statements of qualifications including organizational structures, QA manuals, and standard operating procedures, which can be made available upon request.

Samples were analyzed according to the *Facility-Wide SAP for RVAAP* (USACE 1996a) and the *SAP Addendum for the Phase II Remedial Investigation at Winklepeck Burning Grounds and Determination of Facility-Wide Background at RVAAP* (USACE 1998a). Prepared in accordance with USACE and EPA guidance, the SAP outlines the organization, objectives, intended data uses, and quality assurance/quality control (QA/QC) activities to achieve the desired DQOs and maintain the defensibility of the data. Project DQOs were established in accordance with EPA Region V guidance, and requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for WBG are consistent with EPA requirements for National Priorities List sites. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix E presents an assessment of those objectives as they apply to the analytical program.

Strict adherence to the requirements set forth in the SAP was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with EPA SW-846 (EPA 1990a), *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, analytical protocols. EPA SW-846 chemical analytical procedures were followed for the analyses of metals, VOCs, SVOCs, pesticides, PCBs, explosives, and cyanide. Laboratories were required to comply with all methods as written; recommendations were considered requirements.

The requisite number of QA/QC samples were obtained during the Phase II RI (refer to Appendix E). Quality control (QC) samples for this project included field blanks, trip blanks, field duplicates, laboratory method blanks, laboratory control samples, laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples. Field blanks, consisting of potable water used in the decontamination process, equipment rinsate blanks, and trip blanks, were submitted for analysis along with field duplicate (co-located) samples to provide a means to assess the quality of the data resulting from the field sampling program. Field blank samples were analyzed to determine procedural contamination at the site that may contribute to sample contamination. Equipment rinsate blanks were used to assess the adequacy of equipment decontamination processes for groundwater sample collection. Trip blanks were used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage. Field duplicate samples were analyzed to determine sample heterogeneity and sampling methodology reproducibility. Laboratory method blanks and laboratory control samples were employed to determine the accuracy and precision of the analytical method

as implemented by the laboratory. MSs provided information about the effect of the sample matrix on the measurement methodology. Laboratory sample duplicates and MSDs assisted in determining the analytical reproducibility and precision of the analysis for the samples of interest. Evaluation of these QC measures and their contribution to documenting the project data quality is provided in Appendix E as the project Quality Control Summary Report (QCSR).

SAIC is the custodian of the project file and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms. These files will remain in a secure area under the custody of the SAIC Project Manager, until they are transferred to the USACE Louisville District and RVAAP. Analytical data reports from Quanterra Laboratory have been forwarded to the USACE-CX laboratory for QA review and comparison. Quanterra will retain all original raw data information (both hard copy and electronic) in a secure area under the custody of the Laboratory Project Manager.

2.5.3 Data Review, Validation, and Quality Assessment

Samples were properly packaged for shipment and dispatched to Quanterra Laboratory for analysis. A separate signed custody record was enclosed with each shipment. Samples are accompanied by properly completed chain-of-custody forms, with sample numbers and locations listed. When transferring the possession of samples, the individuals relinquishing and receiving signed, dated, and noted the time on the record. All shipments were in compliance with applicable Department of Transportation regulations for environmental samples.

Data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the project SAP and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance.

Quanterra Laboratories performed in-house analytical data reduction under the direction of the Laboratory Project Manager and QA Officer. These individuals were responsible for assessing data quality and informing SAIC and USACE of any data that were considered "unacceptable" or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and standard operating procedures. Data reduction, review, and reporting by the laboratory were conducted as follows:

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the Laboratory Project Manager.
- The Laboratory Project Manager completed a thorough review of all reports.
- Final reports were generated by the Laboratory Project Manager.
- Data were then delivered to SAIC data validation, and copies of all data packages were forwarded to the USACE for evaluation and preparation of QA and data validation documents.

Quanterra Laboratory prepared and retained full analytical and QC documentation for the project in both hard (paper) copy and electronic storage media (e.g., magnetic tape) as directed by the analytical methodologies employed. Quanterra Laboratory provided the following information to SAIC in each analytical data package submitted:

- cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis;
- tabulated results of inorganic and organic compounds identified and quantified; and
- analytical results for QC sample spikes, sample duplicates, initial and continuing calibration verifications of standards and blanks, method blanks, and laboratory control sample information.

A systematic process for data verification and validation was performed by SAIC to ensure that the precision and accuracy of the analytical data were adequate for their intended use. Analytical data validation was performed to minimize the potential of using false positive or false negative results in the decision-making process (i.e., to ensure accurate identification of detected versus non-detected compounds). This approach was consistent with the DQOs for the project and with the analytical methods, and appropriate for determining contaminants of concern and calculating risk. Samples were identified through implementation of “definitive” analytical methods. “Definitive Data” were reported consistent with the deliverables identified in the project SAP. These “Definitive Data” were then validated through the review process outlined in the SAP and are presented in Appendix E.

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