1.0 INTRODUCTION

This report documents the results of the Phase II Remedial Investigation (RI) for Load Line 2 at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio (Figures 1-1 and 1-2). The Phase II RI was conducted under the U.S. Department of Defense (DoD) Installation Restoration Program (IRP) by Science Applications International Corporation (SAIC) and their subcontractors, under contract number F44650-99-D-0007, Delivery Order No. CY01, with the U.S. Army Corps of Engineers (USACE), Louisville District. The Phase II RI was conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) following work plans reviewed and commented on by the Ohio Environmental Protection Agency (Ohio EPA).

This document summarizes the results of the Phase II RI field activities conducted from July to September 2001 at Load Line 2. The field program, environmental setting, and nature and extent of contamination are discussed. Contaminant fate and transport modeling, a screening human health risk assessment (SHHRA), and a screening ecological risk assessment (SERA) are used to develop a revised conceptual model for Load Line 2 to support the investigation summary and conclusions that are the framework for decisions regarding future IRP actions at Load Line 2.

1.1 PURPOSE AND SCOPE

Figure 1-3 presents the approach to implementing the CERCLA process under the guidance of the IRP. Priorities for environmental restoration at Areas of Concern (AOCs) at RVAAP are based on their relative potential threat to human health and the environment, derived from Relative Risk Site Evaluations (RRSEs). Thirty-eight AOCs were identified in the Preliminary Assessment for RVAAP, Ravenna, Ohio (USACE 1996a). Thirteen new AOCs were identified in 1998 as a result of additional records searches and site walkovers. These were ranked by the U.S. Army Center for Health Promotion and Preventive Medicine and entered into the Defense Sites Environmental Restoration Tracking System. Those AOCs ranked as high-priority sites (i.e., those with high RRSE scores) are targeted first for characterization (e.g., Phase I RIs) and remedial actions. Medium- and low-priority sites will be characterized to the extent required to develop a remedial decision following completion of characterization for high-priority AOCs. Investigations and remedial actions under the CERCLA process are implemented at the AOCs in order of priority as funding is available or unless other priorities surface, such as land use needs.

The purpose of the Phase II RI is to determine the nature and extent of contamination so that quantitative human health risk assessments and ERAs can be performed. Depending upon the outcome of the risk assessments, an AOC will either require no further action (NFA) or will be the subject of a Feasibility Study (FS) to evaluate potential remedies and future actions.

The scope of this investigation is to determine the extent of contamination in affected media (i.e., soils, sediments, surface water, and groundwater) identified during the Phase I RI at Load Line 2 (USACE 1998a). The primary objectives of the Phase II RI are as follows.

- Characterize the physical environment of Load Line 2 and its surroundings to the extent necessary to define potential contaminant transport pathways and risk receptor populations.

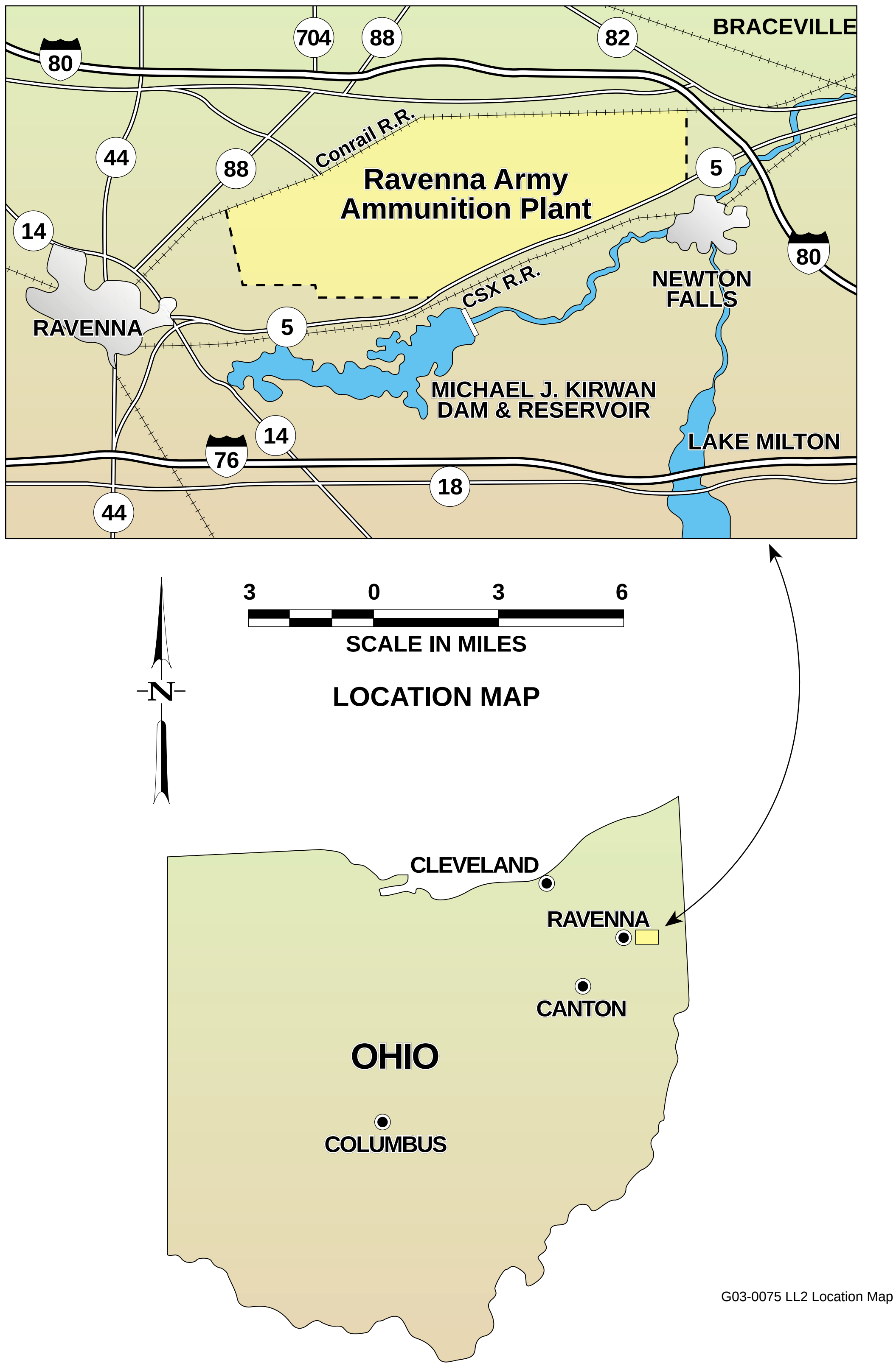


Figure 1-1. General Location and Orientation of RVAAP

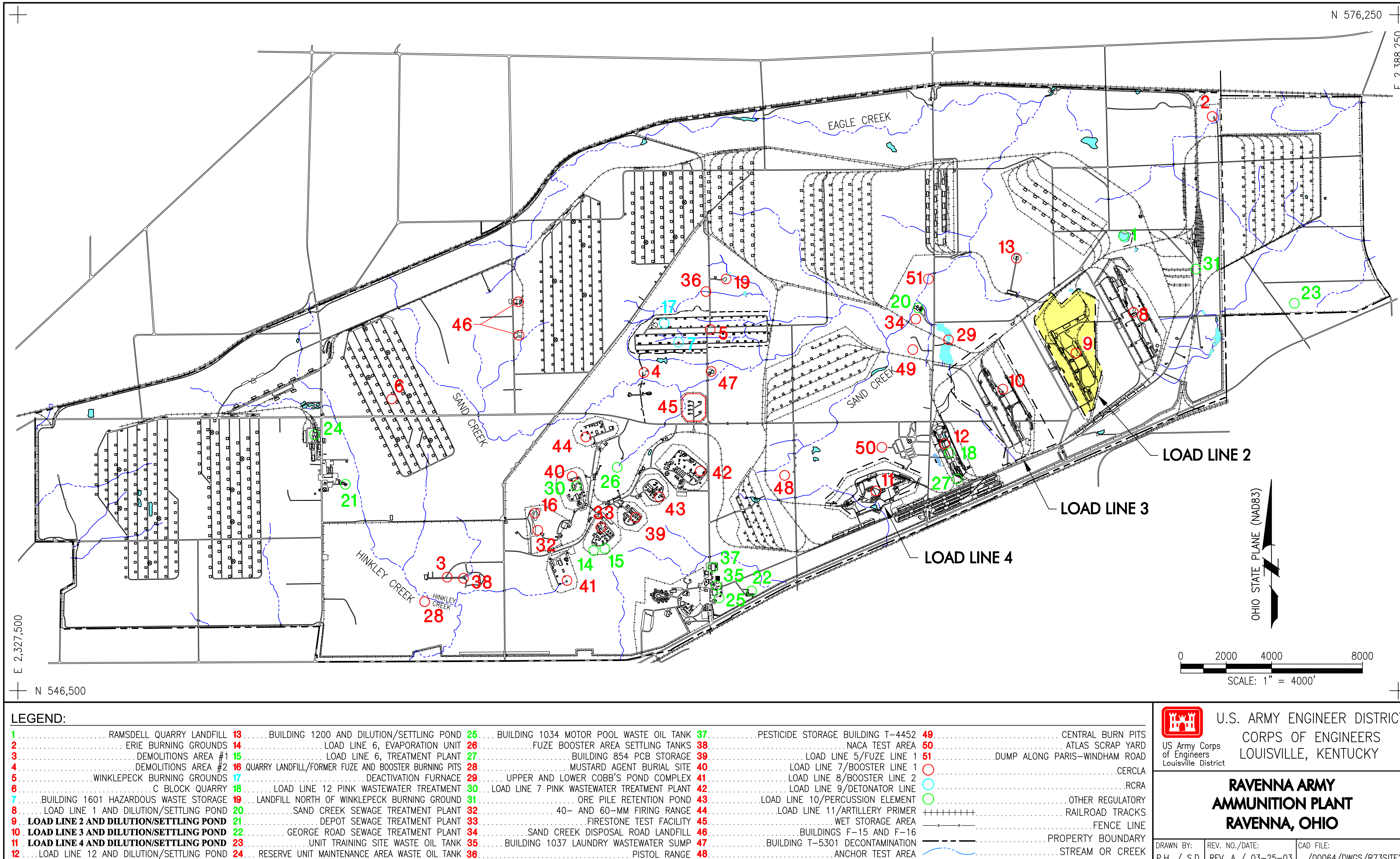
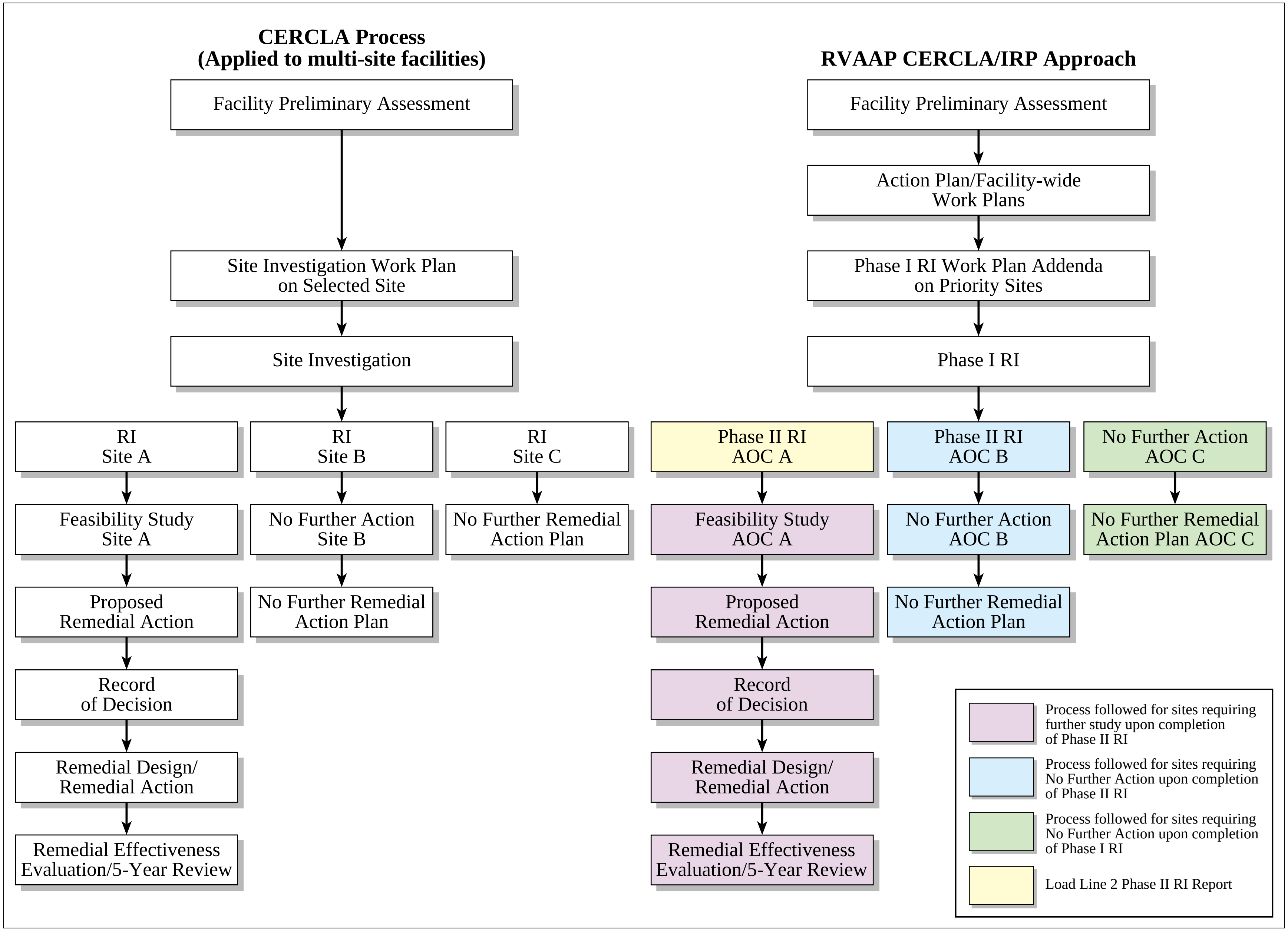


Figure 1-2. RVAAP Facility Map



G03-0075 LL2 CERCLA Approach

Figure 1-3. CERCLA Approach at RVAAP

- Characterize the sources of contamination at Load Line 2, sufficient to screen and evaluate remedial alternatives in a subsequent FS. Data on source locations, types and concentrations of contaminants, potential release mechanisms, physical and chemical properties of contaminants present, and geotechnical characteristics of environmental media will be collected and evaluated.

- Identify whether releases of contamination beyond the AOC boundary are occurring, by collecting environmental samples (i.e., surface water, sediment, and groundwater) downstream or downgradient of the AOC boundary within exit conveyances and using applicable historical information.

- Characterize nature and extent of contamination at Load Line 2 such that risk assessments can be conducted to evaluate the potential threats to human health and the environment and to develop risk-based remedial goal options (RGOs) for use in determining areas that may require remediation and for evaluating remedial alternatives in a subsequent FS.

- Provide preliminary recommendations for any additional investigations and/or actions.

To meet the primary project objectives, investigation-specific data quality objectives (DQOs) were developed using the approach presented in the Facility-wide Sampling and Analysis Plan (SAP) (USACE 2001a). The DQOs specific to the Load Line 2 Phase II RI are discussed in Section 1.4.

The investigation approach for the Phase II RI at Load Line 2 involved a combination of field and laboratory activities to characterize the AOC. Field investigation techniques included soil boring and sampling, as well as sampling of surface water, sediment, and groundwater. The field program was conducted in accordance with the Facility-wide SAP (USACE 2001a) and the SAP Addendum No. 1 for the Phase II Remedial Investigation of Load Lines 2, 3, and 4 (USACE 2001b).

1.2 GENERAL FACILITY DESCRIPTION

1.2.1 Historical Mission and Current Status

RVAAP is a government-owned, contractor-operated facility located in northeastern Ohio within east-central Portage County and southwestern Trumbull County. The facility is located approximately 37 km (23 miles) east of the city of Akron, 4.8 km (3 miles) east-northeast of the city of Ravenna, and approximately 1.6 km (1 mile) northwest of the town of Newton Falls. The installation consists of 8,668.3 ha (21,419 acres) contained in a 17.7-km (11-mile) long, 5.6-km (3.5-mile)-wide tract bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garretsville and Berry Roads on the west; and the CONRAIL Railroad on the north (see Figures 1-1 and 1-2). The installation is surrounded by several less populous communities: Windham on the north, Garrettsville 9.6 km (6 miles) to the northwest, Newton Falls 1.6 km (1 mile) to the east, Charlestown to the southwest, and Wayland 4.8 km (3 miles) southeast.

RVAAP was constructed in 1940 and 1941 with the primary missions of depot storage and ammunition loading during World War II. Industrial operations at RVAAP consisted of 12 munitions-assembly facilities referred to as “load lines.” Load Lines 1 through 4 were used to melt and load trinitrotoluene (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls would be cleaned with water and steam. The liquid, containing TNT and Composition B, was known as “pink water” for its characteristic color. Pink water was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers.

In 1950, the facility was placed in standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with storage of munitions. Production activities were resumed during the Korean Conflict (July 1954 to October 1957) and again during the Vietnam Conflict (May 1968 to August 1972). In addition to production missions, various demilitarization activities were conducted at facilities constructed at Load Lines 1, 2, 3, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at RVAAP include sites that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Potential contaminants at these AOCs include explosives, propellants, metals, waste oils, and sanitary waste. Other types of AOCs present at RVAAP include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities.

In 1992, the status of RVAAP changed from inactive-maintained to modified caretaker. The only activities still being carried out from the wartime era are the storage of bulk explosives and propellants and the infrequent demolition of unexploded ordnance (UXO) found at the installation. The Army is also overseeing the reclamation of railroad track, telephone line, and steel for re-use or recycling. The Army has completed the demolition of excess buildings at Load Lines 1 and 12, and is currently conducting demolition activities at Load Line 2, which includes the removal of friable asbestos. RVAAP's operations and mission-related activities are directed by the Operations Support Command (OSC). Environmental restoration activities at RVAAP are conducted under the auspices of the IRP. As of January 2003, oversight and funding responsibilities for the IRP were transferred from the OSC to the U.S. Army Environmental Center (AEC). In addition to Army mission-related and IRP activities, a large portion of RVAAP is currently used by the Ohio Army National Guard (OHARNG) for training missions, as discussed in Section 1.2.2.

1.2.2 Demography and Land Use

Population statistics from the 2000 Census state that the total populations of Portage and Trumbull Counties are 152,061 and 225,116, respectively. Population centers closest to RVAAP are Ravenna, with a population of 11,771, and Newton Falls, with a population of 5,002. The RVAAP facility is located in a rural area and is not close to any major industrial or developed areas. Approximately 55% of Portage County, in which the majority of RVAAP is located, consists of either woodland or farmland acreage. The Michael J. Kirwan Reservoir (also known as West Branch Reservoir) is the closest major recreational area and is located adjacent to the western half of RVAAP, south of State Route 5.

Until May 1999, about 1,024 ha (2,533 acres) of land and some existing facilities at RVAAP were used by the National Guard Bureau (NGB) for training purposes administered by OHARNG. Training and related activities include field operations and bivouac training, convoy training, equipment maintenance, and storage of heavy equipment. In a Memorandum of Agreement (MOA) dated December 1998, 6,544 ha (16,164 acres) of land was transferred from the Army OSC to NGB, effective May 1999, for expanded training missions. On May 13, 2002, an additional 3,774 acres of land was transferred from OSC to NGB via an amendment to the MOA. Approximately 1,481 acres of property remain under the control of RVAAP; this acreage includes AOCs and active mission areas (Figure 1-4). As AOCs are remediated, transfer of the remaining acreage to the NGB will occur. The OHARNG has prepared a

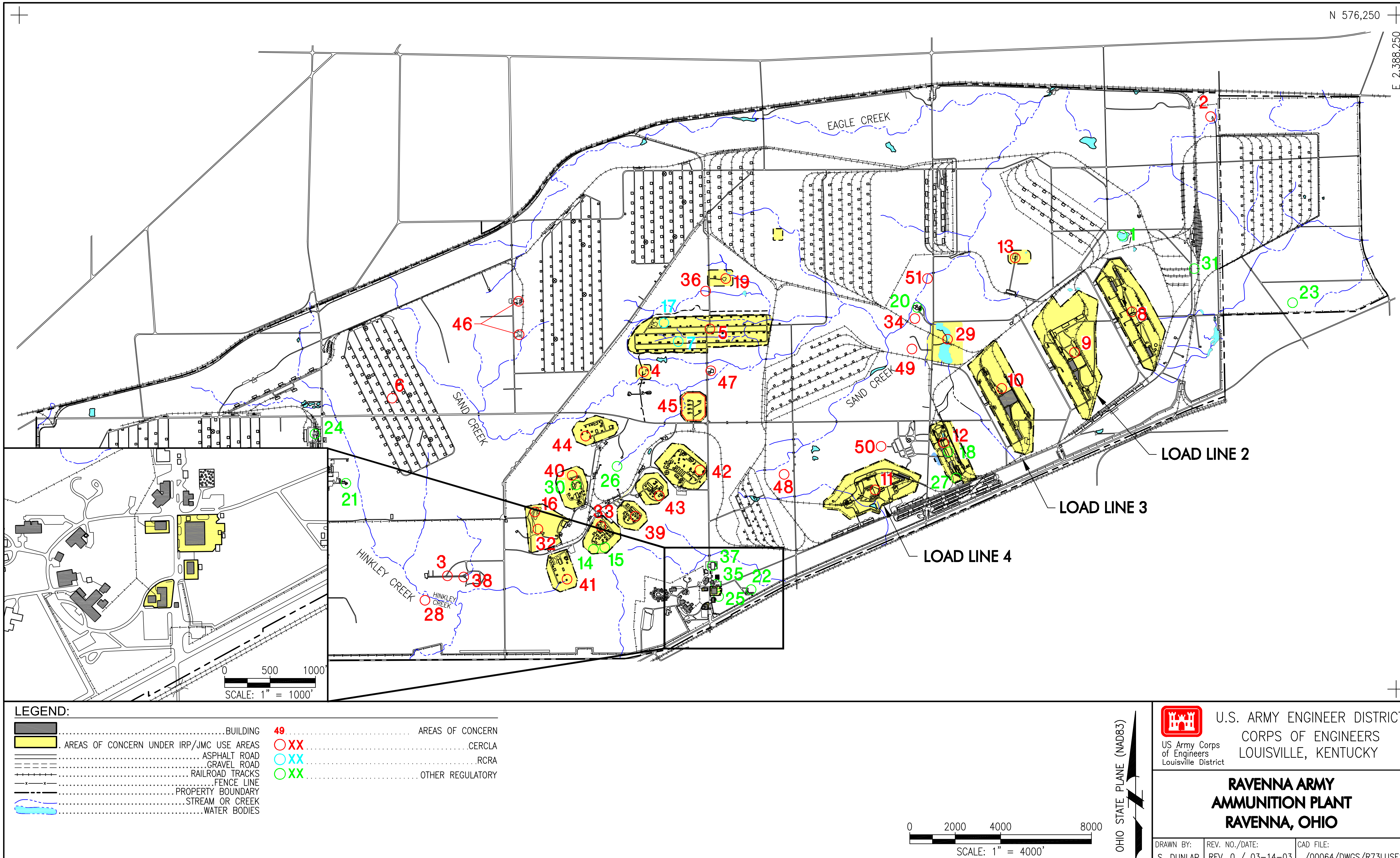


Figure 1-4. Current Land Use at RVAAP

comprehensive Environmental Assessment and an Integrated Natural Resources Management Plan, which address future uses of the property. These uses include two live-fire rifle ranges, hand grenade practice and qualification ranges, a light demolition range, and two armored vehicle maneuver areas. Additional field support and cantonment facilities will be constructed to support future training.

1.3 LOAD LINE 2 SITE DESCRIPTION

A detailed history of process operations and waste processes for the original 38 identified AOCs at RVAAP, including Load Line 2, is presented in the Preliminary Assessment (PA) for RVAAP (USACE 1996a). The following is a summary of the history and related contaminants for Load Line 2.

1.3.1 Operational History

Production Operations

Load Line 2 (Figure 1-5) was used to melt and load TNT and Composition B into large-caliber shells and bombs. The line operated during World War II, from 1951 to 1957, and again from 1969 to 1971. During its operational history, Load Line 2 produced about 10 million munitions. Table 1-1 provides an operational chronology for Load Line 2.

Table 1-1. Operations Chronology for Load Line 2

Munitions	Quantities
World War II Era Production	
155-mm projectile 8-in. projectile 240-mm projectile 4.5-in. projectile Bomb, 100 lb 6-in. projectile	5,100,830 665,499 109,518 65,865 48,415 32,879 Total = 6,023,006
Late 1940s and 1951 to 1957 Demilitarization Activities	
Cartridge case reclamation Debanding and TNT washout/recovery	NA 1,800,000 kg of TNT salvaged
1951 to 1957 Production	
M107, high explosive, 155-mm projectile (Load Lines 2 and 3) M101, high explosive, 155-mm projectile (Load Lines 2 and 3)	5,619,243 256,585 Total = 5,875,828
M106, 8-in. projectile M73, 120-mm projectile M101, 155-mm projectile	946,922 876,947 63,502 Total = 1,887,371
1969 to 1971 Production	
175-mm projectile (TNT charge)	Total = 372,803

NA = Not available.
TNT = Trinitrotoluene.

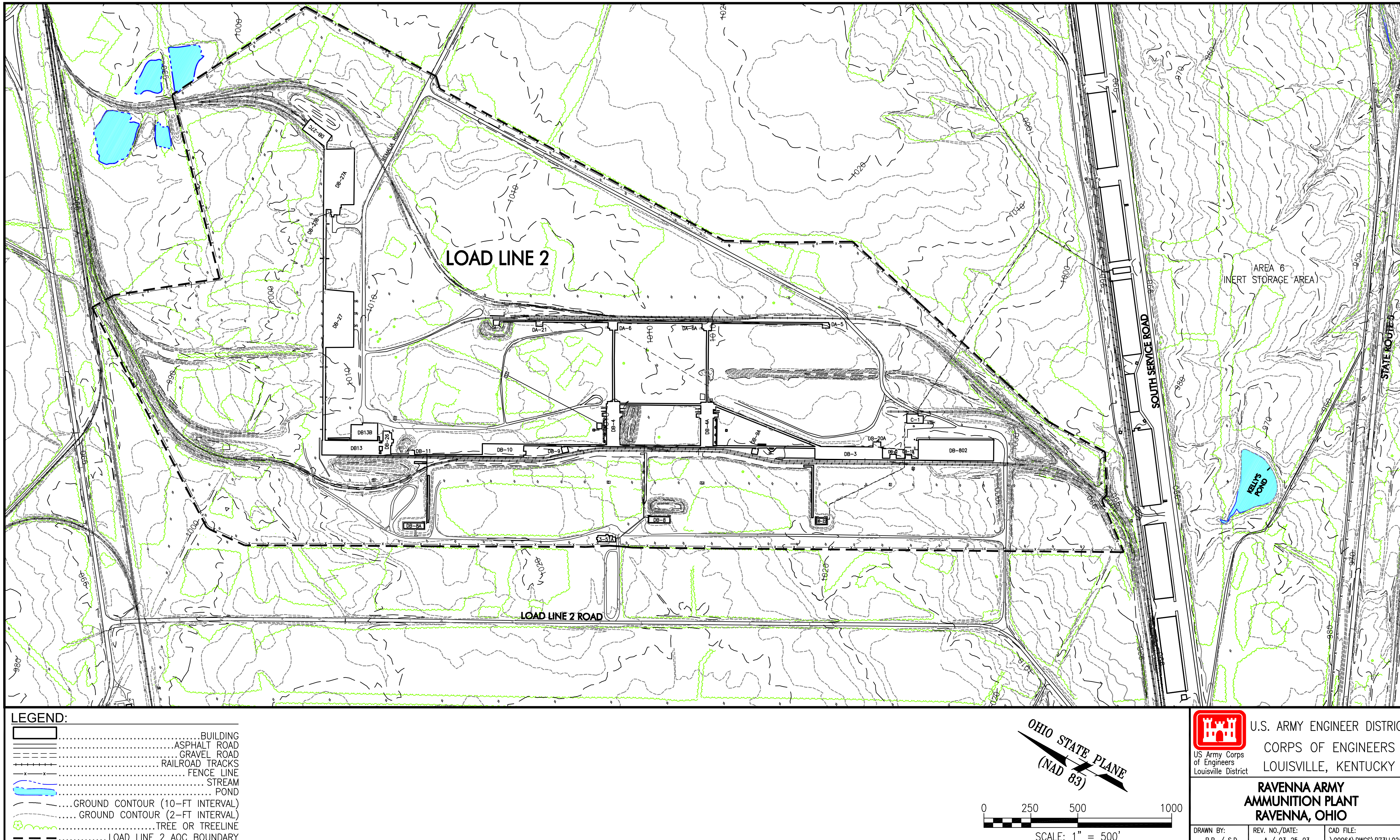


Figure 1-5. Load Line 2 Site Map

During operations, bulk TNT in granular form was offloaded at Buildings DA-6 and DA-6A for screening and preparation. Bulk hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) were received in chunk or nugget form and were manually examined to remove any foreign material. Following preparation, bulk explosive was manually transported in wheeled carriers through a covered walkway to the melt-pour buildings (DA-4 and DA-4A) for processing and loading into shells. Bulk explosive was manually introduced to steam-jacketed melting kettles located on the third floor of the buildings and piped to loading bays on the first floor. The primary charge was loaded into the shells and they were staged in finishing/cooling bays also located on the first floors of the melt-pour buildings. Funnel removal, manual topping of the primary charge, and face off operations were conducted in these areas. Upon completion of primary charge loading, shells were transported to Building DB-10 for drilling operations for booster charges or other preparation steps depending on the type of munition. Drilling operations utilized vacuum equipment to contain explosive dust, which was piped to exterior dust collection units located along the north side of Building DB-10. Radiography equipment used to provide quality assurance (QA) of the primary charge was located in Building DB-26. Buildings DB-13A, -13B, and -13C housed packaging and shipping operations. Shell preparation operations, including cleaning and painting, were contained in Building DB-3. Bulk explosive carrier washout activities were conducted in Building DB-25; effluent was directed to an above-grade concrete settling tank immediately south of the building, which discharged to an unlined drainage ditch.

In a 1950s phase of construction, two large cyclic-heating buildings (DB-27 and DB-27A), associated heating, ventilation, and air conditioning (HVAC) facilities (DB-27B), and new shipping facility (DB-27C) were constructed along the north end of the load line. Loaded shells were placed in the cyclic-heating buildings and subjected to alternating heating and cooling cycles to re-crystallize the primary charge; thus increasing its density and explosive force.

Other ancillary facilities include

- Buildings DB-8, DB-8A, and DB-22 - change houses, offices, and cafeteria facilities;
- Building DB-802 - receiving, inert storage, shell preparation;
- Building DC-1 - load line steam plant and power house;
- Buildings DA-28 and DB-29 - elevator machine houses; and
- Physical plant service buildings (DA-5, DA-7, DA-21, DB-2, DB-9/9A, DB-11, DB-19, and DB-20).

When the facility was at full capacity, Load Line 2 generated approximately 3,192,000 L (842,700 gal) of pink water per month (Jacobs Engineering 1989) from washdown and steam decontamination of equipment. Pink water generated from the munitions-assembly operations was collected in concrete sumps located throughout the load line, which were connected to settling tanks. After settling, the water was pumped by low-pressure steam ejectors into two tanks, approximately 26,200 L (6,900 gal) in volume for cooling. When the water cooled to 80°F, it was pumped through an overhead pipe to a sawdust filtration unit. The sawdust filtration unit consisted of a set of three parallel 3- × 9.1- × 0.9-m (10- × 30- × 3-ft) concrete settling tanks and a set of three 1.5- × 4.6- × 0.9-m (5- × 15- × 3-ft) concrete filtration tanks with vitreous clay filter tiles in the bottom of each tank. The contaminated sawdust used in the filtration tanks and the settled sludge were periodically removed and destroyed at Winklepeck Burning Grounds (WBG). The effluent from the sawdust filtration units was discharged to Kelly's Pond, a triangular, unlined earthen settling impoundment, which is approximately 0.8 ha (2 acres) in size and from 1.8 to 2.4 m (6 to 8 ft) deep. The discharge from the impoundment was channeled to a surface stream that immediately exits the installation south of the load line and, ultimately, empties into the West Branch of the Mahoning River.

In addition, chromic acid was used in Building DB-802 in shell-preparation processes. Chromic acid was stored in an above-grade tank on concrete pedestals located along the eastern side of the building. Some effluents containing chromic acid were reportedly discharged from Building DB-802 into the large central drainage ditch that, ultimately, discharges to Kelly's Pond (USACE 1998). Figure 1-6 presents historical photographs of typical load line production operations.

Demilitarization Operations

Munitions-demilitarization activities (debanding and TNT washout) were conducted during the late 1940s and cartridge reclamation work was performed from 1951 to 1957 (Table 1-1). TNT washout equipment was located in Building DB-4A. Approximately 1.8 million kg (4 million lbs) of TNT was salvaged during demilitarization activities.

Demolition Activities

Demolition activities at Load Line 2 to date (1999 to present) have included removal of asbestos siding and roofing material from most structures. Production equipment has been removed from the major buildings. Piping and overhead conveyor systems have been removed from the extensive walkways connecting the major production buildings. Steel structural framework and concrete structures and buildings remain in place. A very small portion of the floor slabs remains at Building FF-19.

1.3.2 Regulatory Status

Load Line 2 is a high-priority AOC in the current revision of the RVAAP Installation Action Plan (U. S. Army 2003). The priority ranking for Load Line 2 was determined through the RRSE process and the PA, as described in Section 1.3.3 below. Completion of a Phase I RI at the AOC confirmed the presence of contaminants above risk-based screening criteria, indicating the need for additional characterization and human health and ecological risk evaluations as part of a Phase II RI. No other regulations [e.g., Resource Conservation and Recovery Act (RCRA), National Pollutant Discharge Elimination Systems, etc.] pertain to past waste disposal and potential contamination at this AOC.

1.3.3 Previous Investigations at Load Line 2

Table 1-2 presents a summary of the results from previous investigations performed at Load Line 2. Two previous investigations have been conducted: (1) a PA (USACE 1996a) and (2) Phase I Remedial Investigation of High Priority AOCs at RVAAP (USACE 1998a). In addition, sampling of five soil stations was conducted in November 1999 at Load Line 2 to evaluate areas for potential disposal of clean-hard fill material from demolition activities.

Preliminary Assessment

The PA of Load Line 2 performed in 1996 included the load line in the list of high priority sites based on a relative risk ranking methodology. Reevaluation of the Load Line 2 risk ranking was performed at the completion of the Phase I RI and resulted in the site retaining its "High Risk" rating.

Phase I Remedial Investigation

The Phase I RI sampling at Load Line 2 included surface soil and sediment sampling of areas within the AOC (Figure 1-7). In addition, groundwater samples were collected from three well points and two monitoring wells installed downgradient of Kelly's Pond (shown on Figure 1-7). An effort was made in spring 2001 to locate most of the Phase I sampling locations, for Phase II RI planning purposes, and to establish coordinates with a global positioning system (GPS). This effort was required because coordinate surveys of soil and

Booster cavities are being drilled in each shell. All TNT particles and dust are removed by the vaccum system.

Splash pans are cleaned with hot water or steam, resulting in the production of "pink water."

General operations in the melt-pour buildings. Cooled liquid TNT is being poured into each shell.

G03-0075 LL2 Old Photos

Figure 1-6. Typical Historical Operations at RVAAP

Table 1-2. Summary of Historical Analytical Data for Load Line 2

Parameter	Units	Minimum Detect	Maximum Detect	No. of Detects per No. of Results
Sampling Program: Phase I RI (surface soil)				
1,3,5-TNB	mg/kg	0.320	160	6/44
TNT	mg/kg	0.240	12,000	27/44
RDX	mg/kg	0.400	9,800	8/44
HMX	mg/kg	2.8	1,500	4/44
Antimony	mg/kg	0.33	1.2	3/11
Barium	mg/kg	20.2	274	30/30
Beryllium	mg/kg	0.28	2.9	8/11
Cadmium	mg/kg	0.05	22.7	38/44
Chromium	mg/kg	5.5	116	44/44
Cobalt	mg/kg	3.3	17	11/11
Copper	mg/kg	11.7	53.4	11/11
Lead	mg/kg	7	881	44/44
Manganese	mg/kg	146	4,240	44/44
Mercury	mg/kg	0.04	0.94	15/44
Nickel	mg/kg	7	41.9	11/11
Thallium	mg/kg	0.81	7.6	11/11
Vanadium	mg/kg	7.2	24.8	11/11
Zinc	mg/kg	29.8	892	44/44
4,4'-DDE[a]	mg/kg	0.0039	0.081	8/11
PCB-1254[a]	mg/kg	0.150	2.5	6/11
Fluoranthene[a]	mg/kg	0.039	7.7	9/11
Chloroform[a]	mg/kg	0.002	0.003	4/10
Sampling Program: Phase I RI (sediment)				
TNT	mg/kg	0.350	0.86	3/11
Aluminum	mg/kg	3,160	18,000	11/11
Antimony	mg/kg	10.2	10.2	1/3
Arsenic	mg/kg	3.5	19.8	11/11
Barium	mg/kg	32.4	178	11/11
Beryllium	mg/kg	0.32	1.2	3/3
Cadmium	mg/kg	0.26	0.99	5/11
Chromium	mg/kg	6.2	129	11/11
Cobalt	mg/kg	3.7	12.2	3/3
Copper	mg/kg	21.6	167	3/3
Lead	mg/kg	8.8	85.1	11/11
Manganese	mg/kg	74.0	877	11/11
Mercury	mg/kg	0.05	0.09	6/11
Nickel	mg/kg	12.1	36	3/3
Silver	mg/kg	23.1	23.1	1/11
Thallium	mg/kg	1.0	4.2	3/3
Vanadium	mg/kg	9.3	20.1	3/3
Zinc	mg/kg	35.1	299	11/11
Fluoranthene[a]	mg/kg	0.130	30	2/3
Acetone[a]	mg/kg	0.099	0.099	1/3

Table 1-2. Summary of Historical Analytical Data for Load Line 2 (continued)

Parameter	Units	Minimum Detect	Maximum Detect	No. of Detects per No. of Results
Sampling Program: Phase I RI (groundwater)[b]				
2,4-DNT	μg/L	0.34	0.34	1/2
Barium	μg/L	13.3	18.7	2/2
Cobalt	μg/L	0.87	14.7	2/2
Cyanide	μg/L	8.7	8.7	1/2
Manganese	μg/L	106	642	2/2
Nickel	μg/L	3.8	17.9	2/2
Zinc	μg/L	7.8	8.4	2/2
Sampling Program: 1999 Clean-Hard Fill Disposal Areas (surface soil)				
Antimony	mg/kg	3/5	0.56	1.2
Cadmium	mg/kg	3/5	0.51	1.5
Chromium	mg/kg	5/5	8.1	19.9
Cobalt	mg/kg	4/5	5.0	11.2
Copper	mg/kg	5/5	14.1	24.6
Lead	mg/kg	5/5	17.3	94.7
Nickel	mg/kg	5/5	9.0	27.3
Zinc	mg/kg	5/5	56.8	264

[a]Only the most frequently detected constituent in each chemical class (i.e., pesticides, polychlorinated biphenyls, semivolatile organic compounds, and volatile organic compounds) is shown for reference.
[b]Detected explosives, cyanide, and selected trace metals shown for reference.
For Phase Remedial Investigation (RI) data only, constituents identified as site-related contaminants are shown.
HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
TNB = 1,3,5-Trinitrobenzene
TNT = Trinitrotoluene.

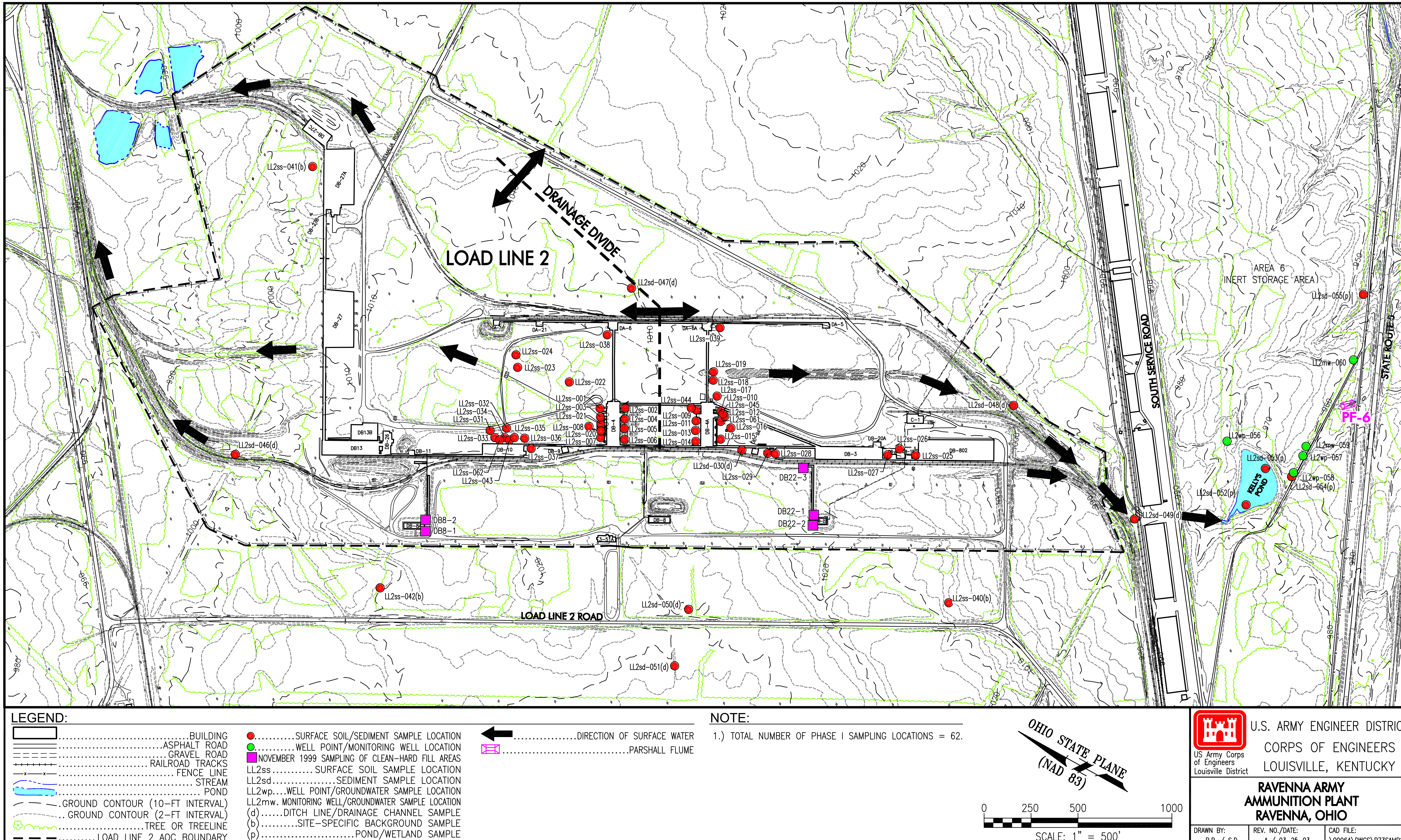


Figure 1-7. Phase I RI and 1999 Clean-Hard Fill Disposal Area Sampling Locations

sediment/surface water sampling stations were not conducted during the Phase I RI. The locations of 33 of 44 Phase I RI soil stations were confirmed (sample station stakes were still present) with GPS during the spring 2001 effort. One sediment station was also located and the coordinates were established. Coordinate data for the remaining Phase I RI stations were established to the best degree of accuracy possible from field sketches and maps. The analytical data are presented in detail in Table 4-19 of Appendix G of the Phase I RI Report (USACE 1998a). A summary of Phase I RI analytical results is presented in Table 1-2. Use of Phase I RI data in nature and extent evaluations and risk assessments is detailed in Section 4.1.5.

Samples were collected at all 44 Phase I RI surface soil locations for explosives analyses. Thirty-seven of these samples were analyzed for an abbreviated list of 11 process-related inorganic analytes. Eleven samples were analyzed for a full target analyte list (TAL) of metals, cyanide, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and pesticides/polychlorinated biphenyls (PCBs).

Elevated concentrations of explosive compounds in surface soil were observed primarily around Buildings DB-4, DB-4A, DA-6A, and DB-10; the settling basins; and the carrier washout building (Building DB-3A). Explosives contamination appeared highly localized around vacuum pumps, doorways, or drains, but did not appear to be present in soil south of Building DB-9A.

Metals above Phase I RI background values (primarily cadmium, chromium, lead, and manganese) were detected throughout the AOC, but were concentrated around Buildings DB-4, DB-4A, and DB-10. Polycyclic aromatic hydrocarbons (PAHs) were detected in surface soil, apparently following the pattern of distribution of explosives around the melt-pour buildings and Building DB-10. PCBs were detected in soil east of Building DB-10, south of Building DB-4A, and immediately south of Building DB-3, with localized occurrences around vacuum pumps and Buildings DB-2 and DB-19.

Eleven ditch and pond sediment samples were collected at Load Line 2 for analysis of 11 site-related inorganic and explosives compounds. Three of these samples received analyses for TAL metals, VOCs, SVOCs, and pesticides/PCBs. Two ditch samples showed explosives contamination: LL2sd-028, near Building DB-9A, and LL2sd-049, in the ditch that exits the load line and discharges to Kelly's Pond. Samples from the pond also contained TNT. The source of this contamination is thought to be pink wastewater effluent discharged directly from the load line, rather than from migration of surface soil contamination. However, storm drains, drainage ditches on the north and west sides of the load line, and the outfall from Kelly's Pond did not have explosives contamination at the locations sampled.

The highest concentrations of inorganic analytes in sediment were observed in samples from Kelly's Pond and in the eastern-most ditch that discharges to the pond. Cadmium, chromium, copper, and lead were found in these sediments. A drainage ditch near Building DB-9A also exhibited a number of metals. PAHs and one PCB compound were found in one sample from Kelly's Pond. Other SVOCs and VOCs were observed at station LL2sd-030, which is located south of Building DB-3A.

Groundwater was collected from two monitoring wells and three well points downgradient from Kelly's Pond (LL2mw-059 and LL2mw-060) and subjected to the full suite of analyses. Low concentrations (< 1 μg/L) of dinitrotoluene (DNT) were detected in groundwater at the AOC perimeter. Site-related inorganic analytes detected in groundwater included aluminum, arsenic, barium, cobalt, iron, manganese, nickel, zinc, and cyanide. This assemblage of analytes differs from the most concentrated analytes detected in sediments in Kelly's Pond upgradient from the monitoring wells. Kelly's Pond would be the most immediate upgradient source of contaminants in these wells; therefore, the source of inorganic contamination noted in groundwater may not be related to Kelly's Pond. Site-related organic compounds found in soil and sediment within the AOC were not present in groundwater in the two monitoring wells at the AOC perimeter.

Because the AOC has remained relatively undisturbed since the Phase I RI, these surface soil and sediment data have been included in the assessment of contaminant nature and extent and the risk assessments presented in this Phase II RI report.

Sampling of Potential Clean-Hard Fill Disposal Locations

In November 1999, surface soil sampling was conducted at former change houses DB-8A and DB-22 to evaluate the suitability of these areas for disposal of inert, uncontaminated demolition debris (SAIC 2000). Two samples were collected at Building DB-8A and three samples were collected at Building DB-22 (Figure 1-7). Refusal occurred on bedrock at depths of 0.3 m (1 ft) or less at all locations. Analyses for explosives, TAL metals, SVOCs, VOCs, cyanide, and pesticides/PCBs were conducted. Eight metals were detected above facility-wide background (Table 1-2); only iron, chromium, and lead exceeded U.S. Environmental Protection Agency (EPA) Region 9 residential risk screening criteria [risk = 10-7; hazard index (HI) = 0.1]. Acetone and toluene were detected, although at levels less than risk screening criteria. SVOCs, explosives, propellants, and pesticides/PCBs were not detected. Data collected during this sampling effort have been included in the assessment of contaminant nature and extent and the risk assessments presented in this Phase II RI report.

1.3.4 Chemicals of Potential Concern

Based on available process knowledge and previous investigation results, the primary sources of contamination at Load Line 2 are explosives residues and metals [e.g., TNT, RDX, DNT, HMX, chromium, lead, and manganese] generated from production of munitions and demilitarization operations. The presence of PAHs and PCBs are likely related to general operations of the Load Line 2 physical plant rather than directly to munitions production (e.g., steam plant operations, PCB-bearing paint residues), but are also of potential concern. Surface contamination exists adjacent to process buildings due to explosive and metal residues and the potential for subsurface soil contamination exists in these areas. There is potential for surface soil, sediment, and surface water contamination from the release of large volumes of process effluent (pink water) and runoff containing explosive and metal constituents into unlined earthen drainage ditches. Sediment and surface water contamination by explosive compounds and metals within Kelly's Pond is also possible due to large volumes of process effluents and runoff that were discharged to this surface water body.

1.4 DATA QUALITY OBJECTIVES

The facility-wide conceptual site model (CSM), operational information, historical data and records, and data collected during previous investigations were used to design the Phase II RI sampling effort. The DQO approach, as outlined in the Facility-wide SAP (USACE 2001a), was employed during the scoping and planning process, including problem definition, identifying key decisions, establishing study area boundaries, and chemical data quality requirements. The key decisions for all investigations at RVAAP have been identified in Section 3.2.4 and in Table 3-1 of the Facility-wide SAP (USACE 2001a). The DQOs for the Phase II RI at Load Line 2 were presented in detail in the *Final Phase II Remedial Investigation Sampling and Analysis Plan for Load Lines 2, 3, and 4 at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001c). A summary of the DQOs is presented below for reference purposes in this report.

The purpose of the Phase II RI was to determine the extent of contamination in affected media (i.e., soil, sediment, surface water, and groundwater) identified during the Phase I RI. The specific objectives of the Phase II RI included

- Characterization of the physical environment of Load Line 2 surroundings, to the extent necessary, to define potential contaminant transport pathways and receptor populations.

- Characterization of nature and extent of contamination such that risk evaluations could be conducted and results compared to those from baseline risk assessments at a risk extrapolation reference site (Load Line 1, WBG, or Load Line 12). The risk extrapolation process was developed among the Army, USACE, and Ohio EPA and implemented under RVAAP's Facility-Wide Human Health Risk Assessor's Manual (FWHHRAM) (USACE 2004b).

- Identifying whether releases of contamination beyond the AOC boundary are occurring by collecting environmental samples (i.e., surface water and sediment) downstream of the AOC boundary within exit conveyances and using applicable historical information, including results of the Phase I RI. Data collected prior to the Phase I RI are of limited use due to the lack of corresponding QA/quality control (QC) data and information on detection limits and any verification/validation processes.

- Characterization of sources of contamination at Load Line 2 sufficient to screen and evaluate remedial alternatives in a subsequent FS. Data on source locations, types and concentrations of contaminants, potential release mechanisms, physical and chemical properties of contaminants present, and geotechnical characteristics of environmental media were identified as key data needs.

- Provide recommendations for any additional investigations and/or actions.

Surface Soil. The majority of Phase I RI surface soil samples were analyzed for only a limited suite of site-related metals; additionally, limited numbers of samples for SVOC, VOC, and PCB analyses were collected. Therefore, all site-related contaminants (SRCs) were not fully identified nor characterized by the Phase I RI. The Phase I RI and other historical sampling did not characterize all of the former process areas. To address these data needs, an expanded analytical suite was employed for the Phase II RI. Those areas not previously characterized were specifically targeted for biased sampling in the Phase II RI. In addition, to investigate whether soil contamination is present in those portions of the AOC outside of the former process areas, random grid sampling methods were selected. The methodology for defining exposure units (EUs) outside the former process areas is discussed in Section 4.3. Contaminated surface soil within and adjacent to former process areas was identified as a potential secondary source of contamination to sediment, surface water, and groundwater. Contaminants may be released from surface soil and migrate in storm runoff either in dissolved phase or adsorbed to particulates and/or colloids. To address these data needs and migration pathways, further characterization of known areas of surface soil contamination was planned to define contaminant nature and extent and to provide sufficient data for remedial alternatives analysis in a subsequent FS.

Subsurface Soil. Subsurface soil characterization was not performed in the Phase I RI. During the Phase II RI, characterization of this medium was identified as a data need to determine if leaching processes may be a potential mechanism for contaminant migration to groundwater. Subsurface soil in all process areas was targeted for characterization using biased sampling in conjunction with that for surface soil.

Sediment. Sediment within ditches and tributaries represents a receptor media for contaminants eroded or leached from soil and transported by storm runoff. The surface water system also represents the primary mechanism for contaminant transport off of the AOC. In addition, sediment may function as a transport mechanism, considering that contaminants adsorbed to particulates may be mobilized by surface water flow. Operational data suggested that the ditches in the vicinity of former process areas represented the most likely locations where contaminants may have accumulated through erosional transport. The primary surface water and sediment exit pathways for the northern-most portion of Load Line 2 are to the north via unnamed ditches and tributaries that ultimately feed into Sand Creek. For most of the load line, including the major production buildings, drainage flows through an outlet at the south end of the AOC, through Kelly's Pond, and, subsequently, off of the installation via Parshall flume (PF)-6 (Figure 1-7). The tributaries draining the northern portion of the AOC and Kelly's Pond to the south are also identified as potential accumulation points for contaminants. Previous Phase I RI sampling of sediment within drainage ditches and Kelly's Pond showed detectable concentrations of explosives and elevated concentrations of chromium, lead, and manganese at the southern outlet from the AOC and within the pond. Based on available data and the CSM, these tributaries were specifically targeted for biased sampling.

Surface Water. Surface water represents the likely primary mechanism for mobilization and transport of contamination within and off of the AOCs. Most chemical transport via surface water is presumed to occur along the ditches within the AOC, and is primarily episodic and related to storm events that produce flushing of the surface water system and mobilization of contaminated soil and sediment through erosion. Surface water sampling was not conducted during the Phase I RI at these load lines. Because of these factors, potential transport of contaminants via surface water off of the AOC and the RVAAP facility installation was identified as an unknown element of the CSM to be addressed by the Phase II RI. Drainage ditches near several former process buildings and the tributaries exiting the load line were specifically targeted for biased sampling to be co-located with sediment samples.

Groundwater. Very limited hydrogeologic and analytical data exist for groundwater at Load Line 2. For the purposes of DQO development and investigation planning, it was presumed that groundwater flow patterns at the AOC followed site topography and surface water drainage patterns. Concentrations of some of the principal soil SRCs are substantially elevated above background, indicating that the potential exists for groundwater contamination. Because of the limited available groundwater data, establishing groundwater flow directions and contaminant migration from source areas to groundwater (via leaching or surface water infiltration) was identified as a key data need for the Phase II RI. Installation of monitoring wells and piezometers was planned to target known and suspected source areas with the highest levels of soil contamination. Monitoring wells were also specifically planned along the southern boundary of the load line to determine whether groundwater flow and potential contaminant transport off of the AOC is occurring. In addition to monitoring wells, characterization of unconsolidated zone stratigraphy and to depths of approximately 15 ft was planned using six test pits excavated by a backhoe. Additionally, a facility-wide water level measurement effort, including all new Load Lines 2, 3, and 4 monitoring wells, was identified as a data need to obtain contemporaneous data and to establish general groundwater flow patterns throughout the installation.

Utilities. Storm sewer and sanitary sewer system infrastructures remain in place at Load Line 2. These sewer systems may represent accumulation points for contaminants introduced through building floor drains and sink drains during AOC operations. Reconnaissance of the AOCs and investigations to date indicated that most of the storm and sanitary sewer systems at Load Line 2 were above the water table and were dry. Considering the age of the systems, cracks or gaps in the piping potentially allow groundwater influx or seepage of storm water from the pipes. Thus, if the piping contains accumulated contaminants in sludges or sediment, it may represent a source to groundwater. Also, the system may function as a preferential migration pathway for shallow groundwater transport. Accordingly, a visual and video camera survey was planned to investigate the condition of the system. Sludge or sediment samples were planned at identified accumulation points to investigate if contaminants migrated into the sewer systems from process areas. Also, samples of accumulated water were planned to determine if any identified contaminants are partitioning from sediment or sludge to accumulated water within the pipes and, subsequently, being discharged at outlet locations.

1.5 REPORT ORGANIZATION

This Phase II RI Report is organized to meet Ohio EPA requirements in accordance with EPA, CERCLA Superfund process, and USACE guidance. The report consists of an Executive Summary, Chapters 1.0 through 10.0, and supporting appendices. Chapter 1.0 describes the purpose, objectives, and organization of this report, and provides a description and operational history of Load Line 2. Chapter 2.0 describes the environmental setting at RVAAP and Load Line 2, including the geology, hydrogeology, climate, population, and ecological resources. Chapter 3.0 describes the specific Phase II RI methods used for field data collection and describes the approach to analytical data management and laboratory programs. Chapter 4.0 presents the data generated during the Phase II RI and discusses the occurrence and distribution of contamination at Load Line 2. Chapter 5.0 includes the methodology and results for contaminant fate and transport modeling. Chapters 6.0 and 7.0 present the methodology and results of the human health and ecological risk evaluations. Chapter 8.0 summarizes the results and conclusions of this study and presents lessons learned. Chapter 9.0 presents the recommendations, and Chapter 10.0 provides a list of referenced documents used to support this Phase II RI.

Appendices (A through S) to this report for Load Line 2 contain supporting data collected during the Phase II RI. These appendices consist of soil sampling logs (Appendix A); sediment and surface water sampling logs (Appendix B); piezometer and monitoring well installation and development and sampling logs (Appendixes C and D, respectively); slug test logs and solutions (Appendix F); QA documentation (Appendixes G and H); laboratory and field analytical data (Appendixes I through K); fate and transport modeling results (Appendix L); survey data (Appendix M); sewer line video survey results (Appendix N); ordnance and explosives (OE) avoidance report (Appendix O); investigation-derived waste (IDW) management characterization reports (Appendix P); and supporting data for the SHHRA and screening ERA (SERA) (Appendixes Q and R, respectively); and USACE radiological survey (Appendix S).