1.0 INTRODUCTION

This report documents the results of the Phase II Remedial Investigation (RI) at Load Line 4 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 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 4. 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) and baseline ecological risk assessment (BERA) are used to develop a revised conceptual model for Load Line 4 to support the investigation summary and conclusions that are the framework for decisions regarding future IRP actions at this Area of Concern (AOC).

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 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 the Ravenna Army Ammunition Plant, Ravenna, Ohio (USACE 1996). 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 ecological risk assessment (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 4 (USACE 1996). The primary objectives of the Phase II RI are as follows.

- Characterize the physical environment of Load Line 4 and its surroundings to the extent necessary to define potential contaminant transport pathways and risk receptor populations.

- Characterize the sources of contamination at Load Line 4 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.

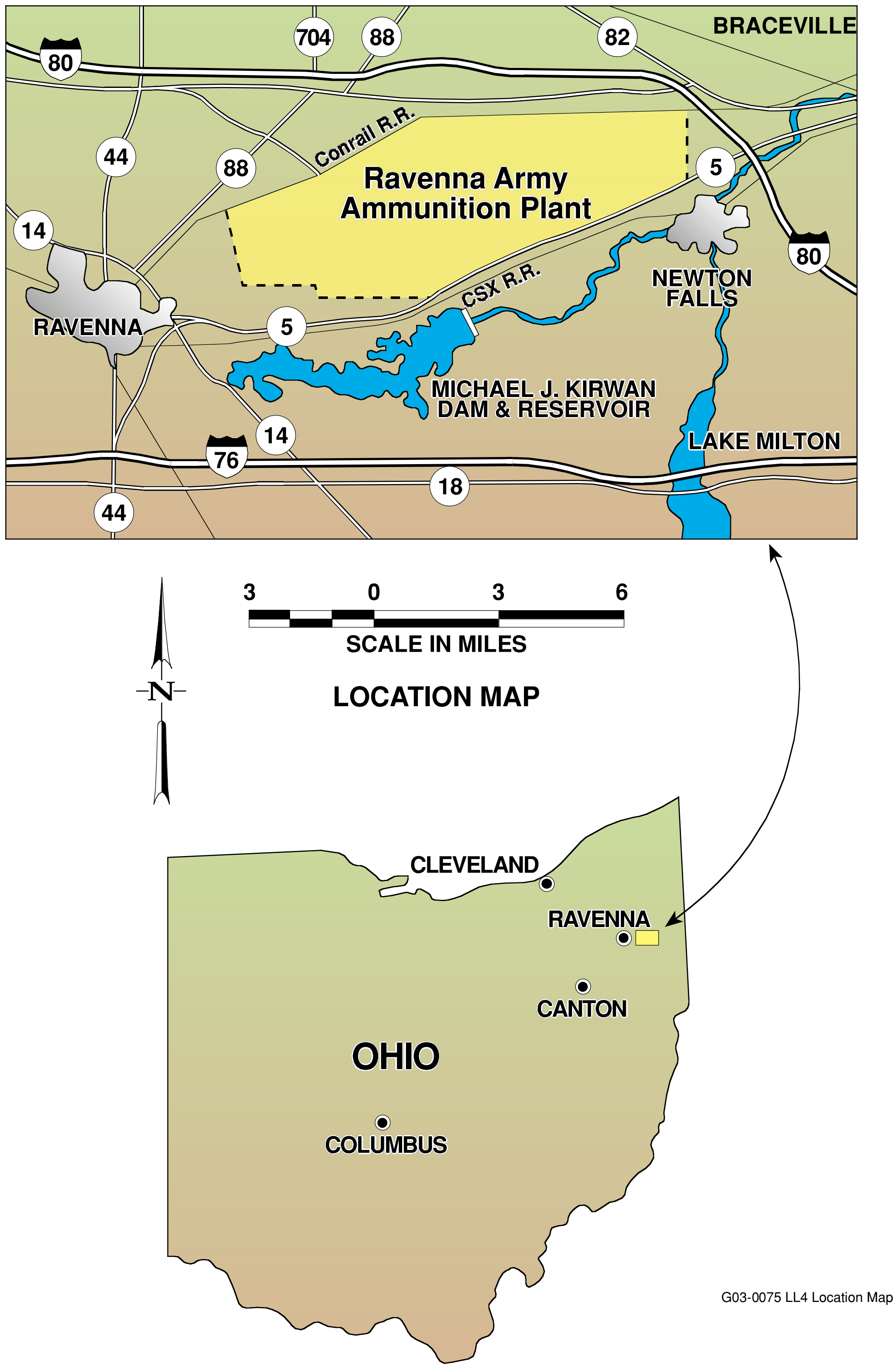


Figure 1-1. General Location and Orientation of RVAAP

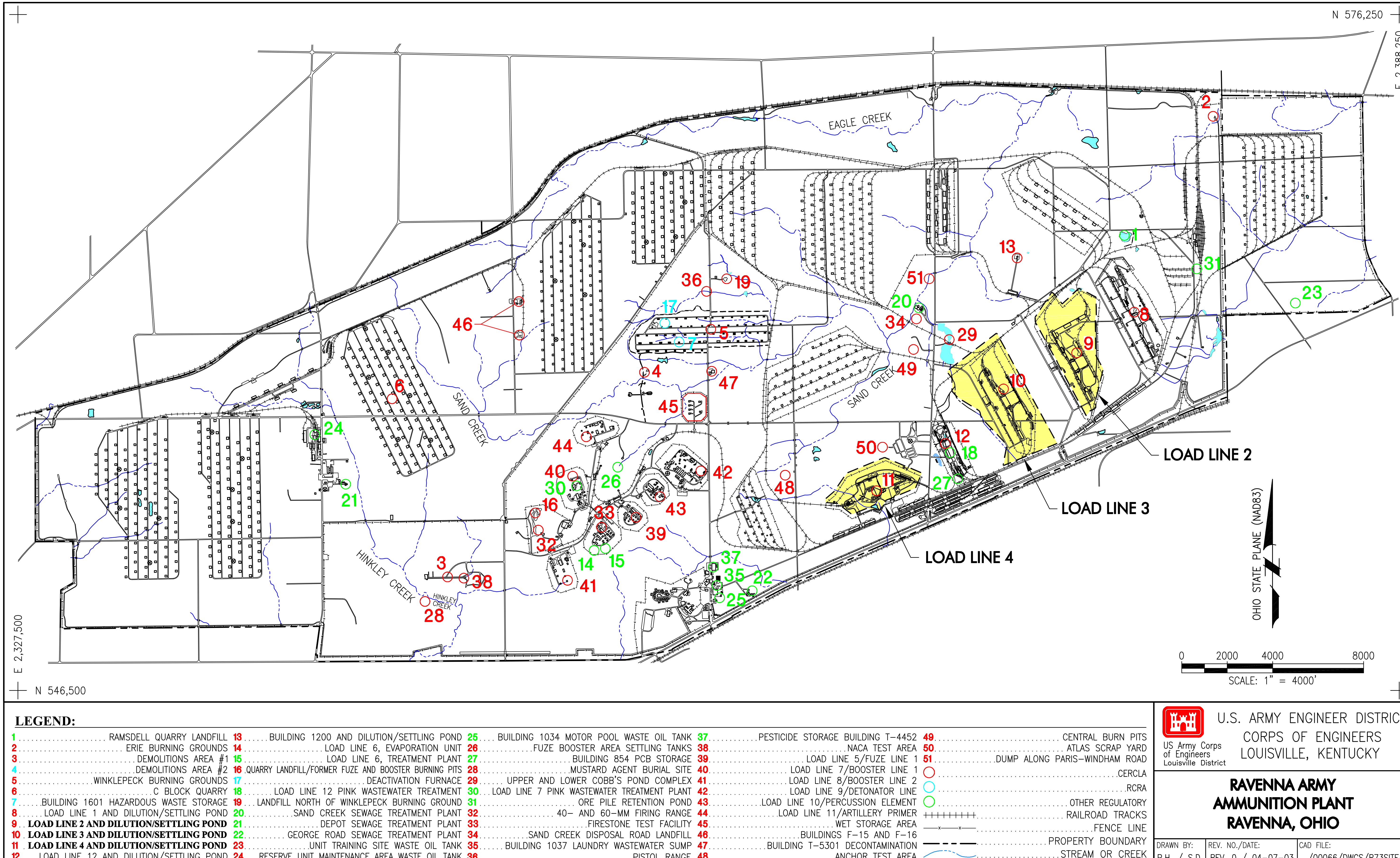
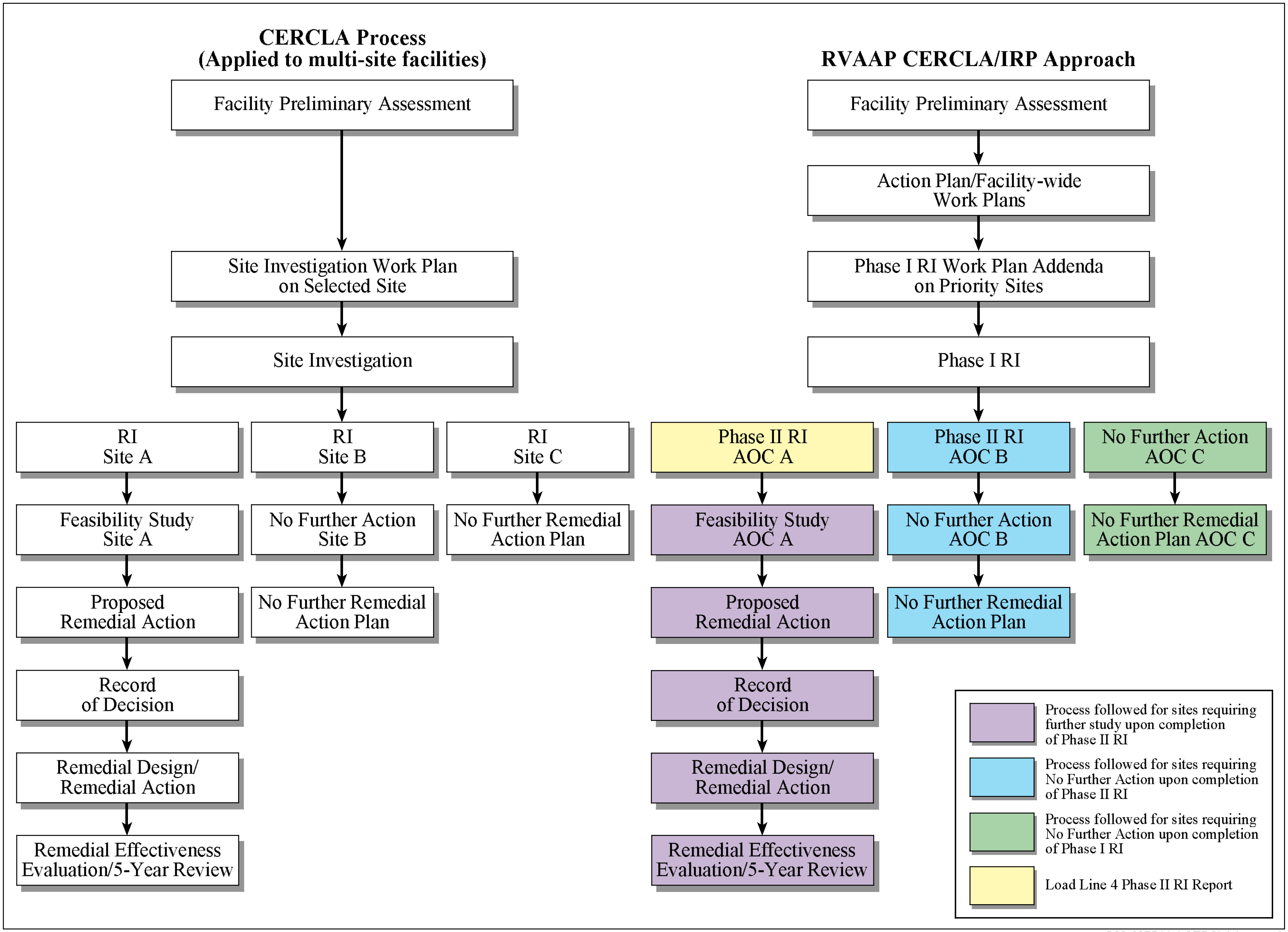


Figure 1-2. RVAAP Facility Map



G03-0075 LL4 CERCLA Approach

Figure 1-3. CERCLA Approach at RVAAP

- 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 4 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 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 2001c). The DQOs specific to the Load Line 4 Phase II RI are discussed in Section 1.4.

The investigation approach for the Phase II RI at Load Line 4 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 2001c) 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. 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, outside of AOCs, 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 the OSC to NGB via an amendment to the MOA. Approximately 1,481 acres of property remain under the control RVAAP; this acreage includes AOCs and active mission areas (Figure 1-4). As AOCs are remediated, transfer of the remaining acreage to NGB will occur. OHARNG has prepared a comprehensive Environmental Assessment and an Integrated Natural Resources Management Plan, which addresses 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.

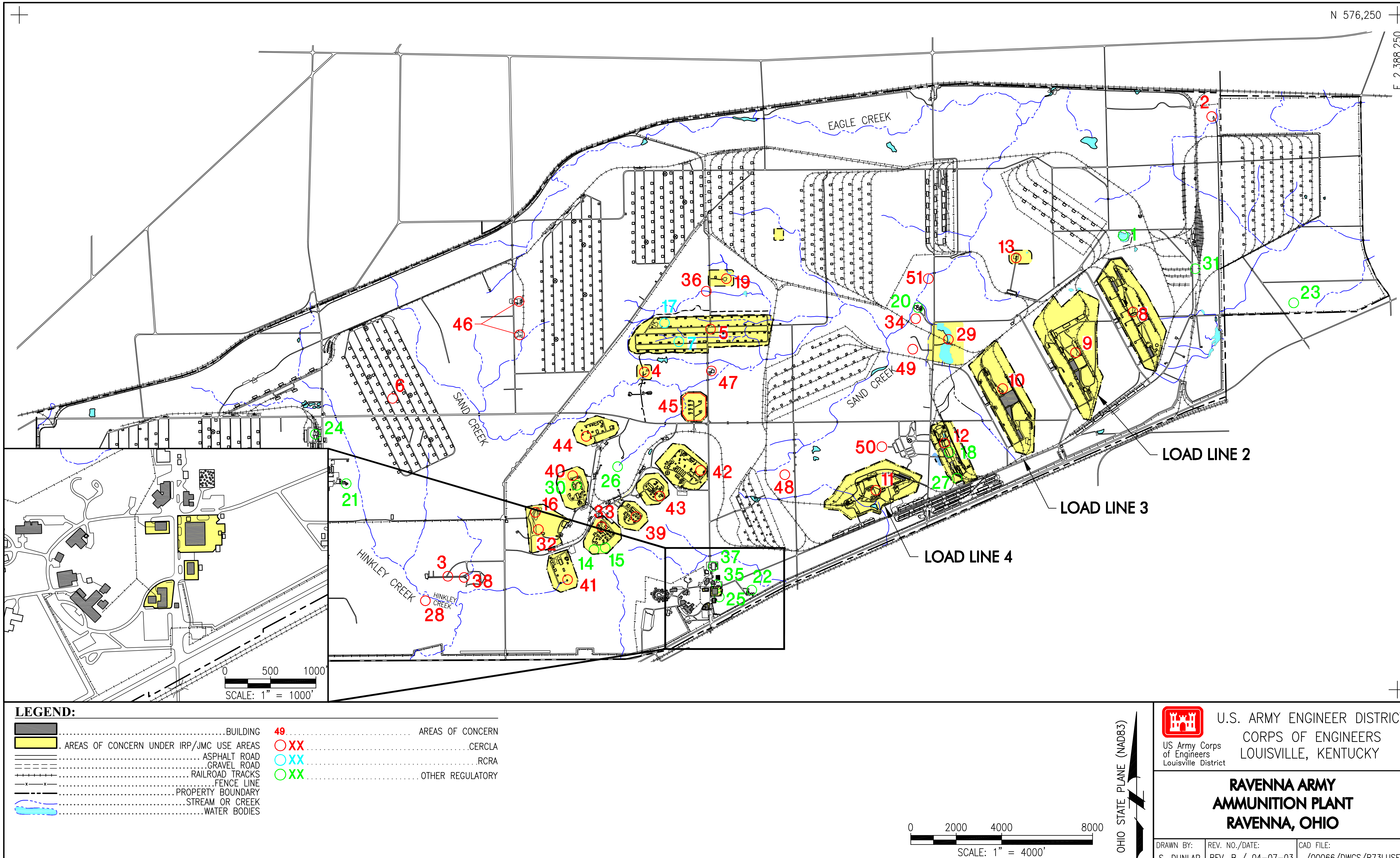


Figure 1-4. Current Land Use at RVAAP

1.3 LOAD LINE 4 SITE DESCRIPTION

A detailed history of process operations and waste processes for the original 38 identified AOCs at RVAAP, including Load Line 4, is presented in the Preliminary Assessment (PA) for RVAAP (USACE 1996). The following is a summary of the history and related contaminants for Load Line 4.

1.3.1 Operational History

Production Operations

Load Line 4 (Figure 1-5) was used to melt and load TNT into large-caliber shells, bombs, and antitank mines. The line operated briefly during World War II and again from 1951 to 1957. During its operational history, Load Line 4 produced about 1.2 million munitions. Table 1-1 provides a summary of munitions produced at Load Line 4. Bulk TNT was offloaded at Building G-16, transported to G-11 for screening, and then to Buildings G-10 or G-15 for additional preparation steps. Following preparation, bulk explosives were transported via a covered walkway to the melt-pour building (G-8) for processing and loading into shells. Once the primary TNT charge was loaded into the shells, they were transported to Buildings G-12 and G-12A for cooling. Funnel removal, face off operations, and drilling operations for booster charges or other preparation steps depending on the type munition were conducted in Building G-13. Explosives dust collection units were located just north of Building G-13. Radiography equipment used to provide quality assurance (QA) of the primary charge was located in Building G-13A. Buildings G-18, G-19, and G-19A housed packing and shipping operations and Building G-9 was used as a magazine and empty transport cart storage. Ancillary facilities include

- Buildings G-6 and G-6A - change house and cafeteria facilities;
- Buildings G-1, G-1A, G-2, and G-3 - inert material receiving and warehousing operations;
- Building G-4 - steam plant and power house;
- Building G-5 - office areas; and
- Buildings G-2, G-7, G-14, and G-17 - physical plant service buildings.

Table 1-1. Operations Chronology for Load Line 4

Munitions	Quantities
World War II Era Production	
8-in. projectile Bomb, 500 lb Bomb, 1,000 lb	70,168 12,482 9,320 Total = 91,970
1951 to 1957 Production	
T27 heavy antitank mine	1,269,262 Total = 1,269,262

When the facility was at full capacity, Load Line 4 generated approximately 3,390,000 L (895,000 gal) of pink water per month (Jacobs Engineering 1989) from washdown and steam decontamination of equipment. Pink water generated from these operations was collected in concrete sumps and pumped via an overhead 6-in. diameter cast iron flume to a settling basin and sawdust filtration unit located southwest of Building G-8. The settling basin consisted of a 9.1- × 9.1- × 0.9-m (10- × 30- × 3-ft) concrete basin divided into three compartments separated by baffles. The sawdust filtration unit consisted of a concrete tank comprised of three compartments measuring about 1.5 × 4.6 × 0.9 m (5 × 15 × 3 ft). The bottom of the compartments

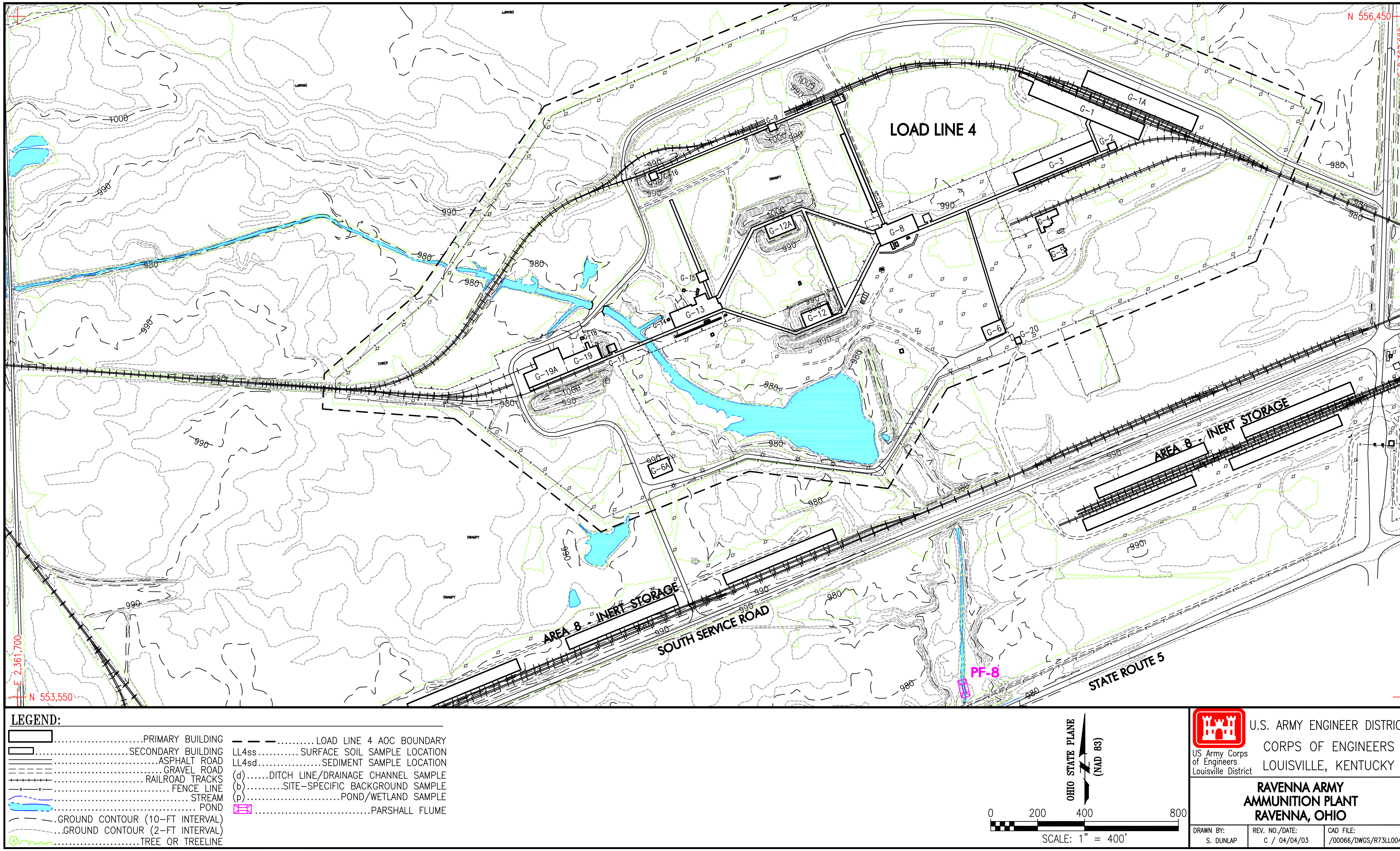


Figure 1-5. Load Line 4 Site Map and Phase I RI Sampling Locations

was lined with vitreous clay filter tiles; each compartment was separated by baffles. Effluent from the filtration unit was discharged to an unlined drainage ditch that flows into a 0.8-ha (2 acre) settling pond within Load Line 4. The pond discharges to a surface stream that exits RVAAP south of the load line.

Solid wastes generated at Load Line 4 during full capacity operations included approximately 11,930 kg (26,305 lbs) per month of explosives-contaminated sawdust and settling sludges, which were periodically removed from the filtration tank and settling basin, along with contaminated combustible wastes (paper, cardboard) and explosives dust. These materials were transported to the Winklepeck Burning Grounds (WBG) and destroyed by thermal treatment. Figure 1-6 presents historical photographs of typical Load Line 4 production operations.

Demolition Activities

No significant demolition activities have occurred at Load Line 4. Rail lines within the AOC have been removed as part of facility-wide reclamation efforts.

1.3.2 Regulatory Status

Load Line 4 is a medium risk AOC, as defined by the RRSE process in the current revision of the RVAAP Installation Action Plan (US Army 2003). The AOC was included as one of 11 high-priority AOCs under the RVAAP IRP for which an integrated Phase I RI was performed (see Section 1.3.3). Completion of the Phase I RI at Load Line 4 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, National Pollutant Discharge Elimination System, etc.] pertain to past waste disposal and potential contamination at this AOC.

1.3.3 Previous Investigations at Load Line 4

Two previous investigations have been conducted: (1) the PA (USACE 1996) and (2) the Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant (USACE 1998).

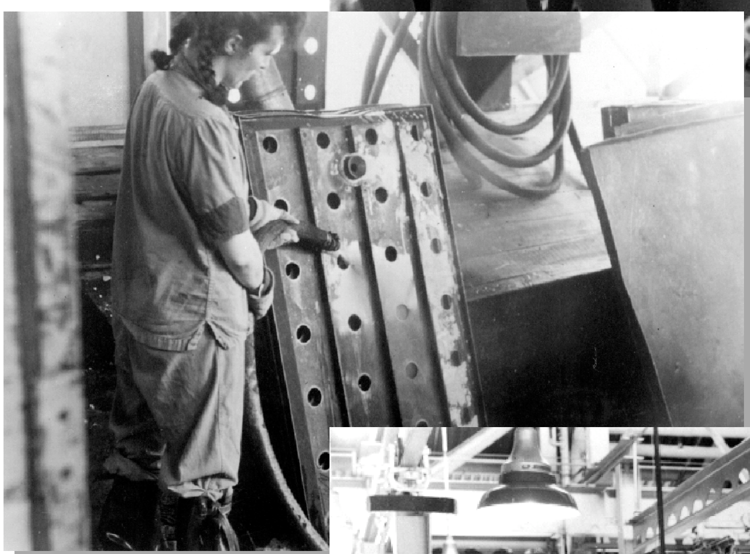
Preliminary Assessment

The PA of Load Line 4 performed in 1996 included the load line in the list of medium priority sites based on the RRSE methodology. The PA cited a small number of surface water results for the main stream through the AOC collected in 1989 during the Preliminary Review/Visual Site Inspection (Jacobs 1989); these results showed detected quantities of TNT (60 µg/L) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (540 µg/L). Evaluation of operational history and the potential for contamination of environmental media resulted in the load line being assigned to a group of 11 high-priority AOCs under the RVAAP IRP.

Phase I Remedial Investigation

The Phase I RI sampling at Load Line 4 included 50 surface soil stations and 14 sediment stations within the AOC (Figure 1-7). Sediment samples were collected at 14 stations from the main stream traversing the AOC, the settling pond, principal drainage ditches from the production area, and in the stream exiting the settling pond. In addition, groundwater samples were collected from three temporary well points installed by direct-push methods; two located downstream of the settling pond, and one located southeast (and presumably downgradient) of the main production area.

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 LL4 Old Photos

Figure 1-6. Typical Historical Operations at RVAAP

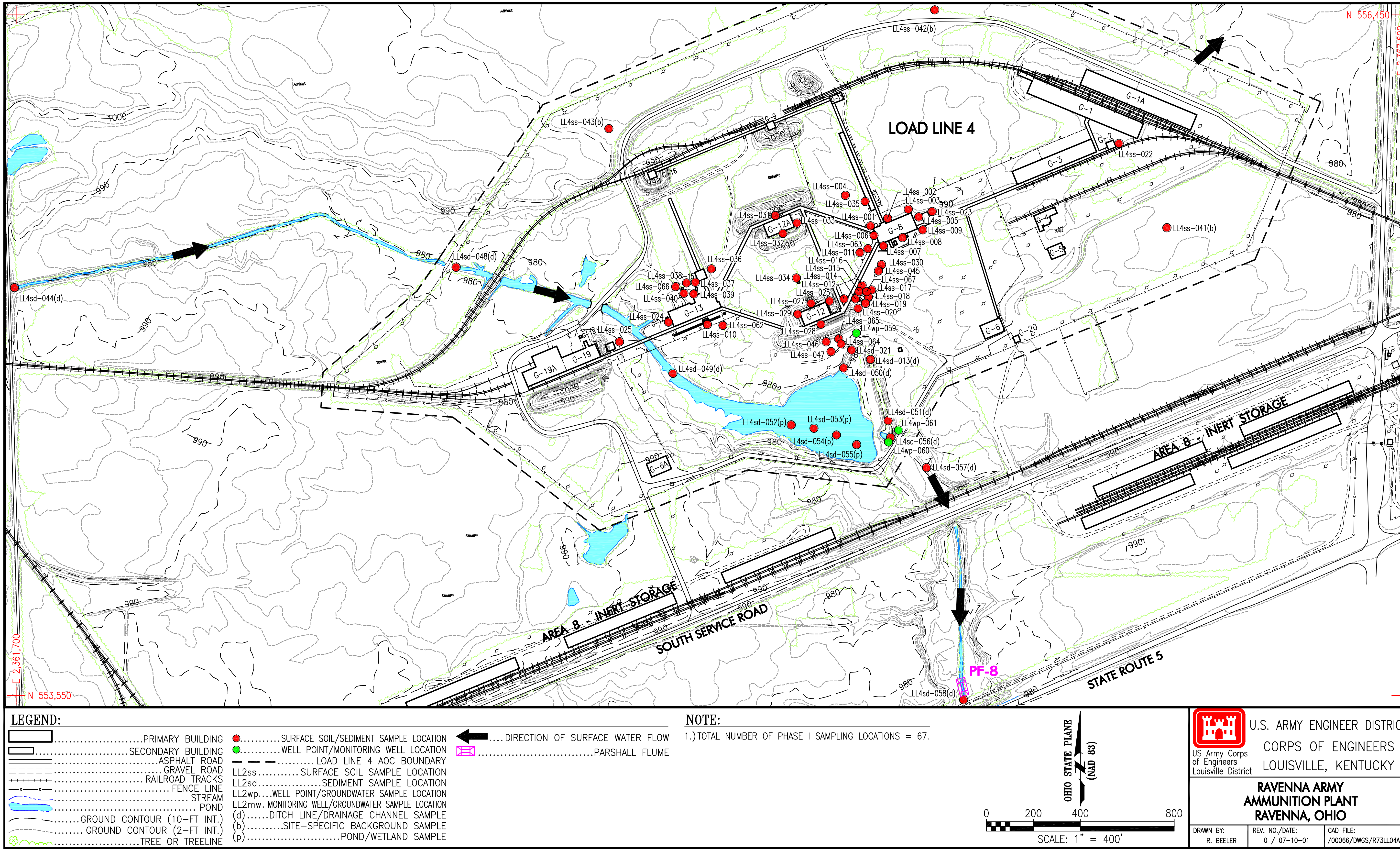


Figure 1-7. Load Line 4 Phase I RI Sampling Locations

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 sediment/surface water sampling stations were not conducted during the Phase I RI. The locations of 33 of 47 Phase I RI soil stations were confirmed (sample station stakes were still present) with GPS during the spring 2001 effort. One ditch sediment station was also located and coordinates 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 4.21 of the Phase I RI Report (USACE 1998). A summary of Phase I RI analytical results is presented in Table 1-2. Use of Phase I RI data in nature and extent assessments is detailed in Section 4.1.5.

Samples were collected at all 47 Phase I RI surface soil locations for analysis for explosives and 11 process-related inorganic analytes. Eleven of the 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 were observed in nine samples associated with Building G-8, the washout facility south of Building G-8, and Buildings G-12, G-12A, and G-13. Inorganic analytes were present in all samples, but were observed at the highest concentrations around Buildings G-8, G-12, G-12A, G-13, and G-17. Beryllium, cadmium, cobalt, lead, nickel, and zinc were the most abundant and concentrated of the metals detected in surface soil. Polycyclic aromatic hydrocarbon (PAH) and pesticide/PCB compounds were the dominant organic constituents and were found in both the southeast and east of Building G-8, the southeast corner of Building G-12, immediately east of Building G-17, and vacuum pump exhaust outlets at the ammunition-cooling building (G-13).

All 14 sediment samples were analyzed for explosive compounds and 11 process-related inorganics. Two samples were also analyzed for a full suite of constituents including TAL metals, cyanide, VOCs, SVOCs, and pesticides/PCBs. Settling pond sediment samples contained no detectable quantities of TNT or other explosives. Low levels of TNT were present in the drainage outlet south of the settling pond and upstream of the AOC where the main stream enters the load line from the west. Arsenic, cadmium, chromium, lead, and zinc were detected in settling pond sediments and drainage ditch sediments; with the highest levels present in the pond. Low concentrations of VOCs were present in one sediment sample from the pond. No other organic constituents were detected.

Groundwater samples collected from the three well points were analyzed for a full suite of TAL metals, cyanide, VOCs, SVOCs, and pesticides/PCBs. Explosives, VOCs, and SVOCs were not detected in any of the well points. Eleven metals and cyanide were detected in one or more well points. A summary of the Phase I RI analytical results is presented in Table 1-2.

Because the AOC has remained relatively undisturbed since the Phase I RI, soils data from the Phase I RI have been included in the assessment of contaminant nature and extent and the risk assessments presented in this Phase II RI report. Likewise, Phase I sediment data are assumed to be representative of site conditions as they exist today and are included in the Phase II evaluations. Phase I groundwater data are not included for any further evaluation purposes because of their age and the fact that samples were not obtained from specification monitoring wells.

1.3.4 Chemicals of Potential Concern

Based on available process knowledge and previous investigation results, the primary sources of contamination at Load Line 4 are explosives residues and metals [e.g., TNT, RDX, dinitrotoluene (DNT), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), cadmium, lead, and zinc] generated from production of munitions. The presence of low levels of PAHs and pesticides and the occurrence of PCBs are likely

Table 1-2. Summary of Historical Analytical Data for Load Line 4

Parameter	Units	Minimum Detect	Maximum Detect	No. of Detects Per No. of Results
Sampling Program: Phase I RI (surface soil)				
2,4,6-TNT	mg/kg	0.24	2.2	9/47
RDX	mg/kg	0.27	0.27	1/47
HMX	mg/kg	1.0	1.0	1/47
Barium	mg/kg	17.3	238	47/47
Beryllium	mg/kg	0.25	3.6	11/11
Cadmium	mg/kg	0.04	5.2	44/47
Chromium	mg/kg	5.2	30.1	47/47
Cobalt	mg/kg	3.0	10.4	11/11
Copper	mg/kg	7.7	106	11/11
Cyanide	mg/kg	0.11	0.51	6/11
Lead	mg/kg	8.1	384	47/47
Manganese	mg/kg	43.5	2,830	47/47
Mercury	mg/kg	0.03	0.16	10/47
Nickel	mg/kg	7.8	32.1	11/11
Thallium	mg/kg	0.46	13.3	11/11
Vanadium	mg/kg	8.9	19.7	11/11
Zinc	mg/kg	25.4	1,850	47/47
4,4'-DDT[a]	mg/kg	0.009	0.23	3/11
PCB-1254	mg/kg	0.11	3.2	3/11
PCB-1260	mg/kg	4.5	4.5	1/11
Fluoranthene[a]	mg/kg	0.038	8.1	7/11
Toluene[a]	mg/kg	0.005	0.12	2/11
Sampling Program: Phase I RI (sediment)				
2,4,6-TNT	mg/kg	0.19	8.7	4/14
Barium	mg/kg	15.8	107	14/14
Beryllium	mg/kg	0.27	0.62	2/2
Cadmium	mg/kg	0.07	0.72	12/14
Cobalt	mg/kg	5.1	9.1	2/2
Copper	mg/kg	10.4	16.2	2/2
Cyanide	mg/kg	0.16	0.16	1/2
Lead	mg/kg	7.8	21.4	14/14
Manganese	mg/kg	91.9	895	14/14
Mercury	mg/kg	0.05	0.11	4/14
Nickel	mg/kg	10.8	18	2/2
Thallium	mg/kg	1.3	1.3	1/2
Vanadium	mg/kg	6.2	15.9	2/2
Zinc	mg/kg	39.1	208	14/14
Acetone[a]	mg/kg	0.25	0.25	1/2
Sampling Program: Phase I RI (groundwater)[b]				
Arsenic	µg/L	5.1	12	3/3
Barium	µg/L	36.1	80	3/3
Beryllium	µg/L	0.33	0.34	3/3
Cobalt	µg/L	1.0	1.6	2/3
Cyanide	µg/L	8.7	8.7	3/3
Lead	µg/L	1.9	1.9	1/3
Manganese	µg/L	183	2,670	3/3
Nickel	µg/L	0.85	3.9	3/3
Zinc	µg/L	10.1	14.2	2/3

[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 RI data, only constituents identified as site-related contaminants are shown.
HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine. RI = Remedial Investigation.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine. TNT = Trinitrotoluene.

related to general operations of the Load Line 4 physical plant rather than directly to munitions production (e.g., steam plant operations, PCB-bearing paint residues), but are also of potential concern. In general, lower levels of contaminants are present at Load Line 4 than at the other major melt-pour lines (Load Lines 1 through 3). 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 the large settling 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 2001c), was employed during the scoping and planning process, including problem definition, identifying key decisions, and 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. The DQOs for the Phase II RI at Load Line 4 were presented in detail in SAP Addendum No. 1 (USACE 2001b). 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 (soil, sediment, surface water, and groundwater) identified during the Phase I RI. The specific objectives of the Phase II RI included the following.

- Characterization of the physical environment of Load Line 4 and its 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 risk reference sites (Load Line 1 or WBG). 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 2004).

- Identifying whether releases of contamination beyond the AOC boundary are occurring by collecting environmental samples (surface water and sediment) downstream of the AOC boundary within exit conveyances and using applicable historical information, including results of the Phase I RI where feasible. Data collected prior to the Phase I RI is of limited use due to 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 4 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 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 4.1. 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 may migrate in storm runoff either in dissolved phase or be 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. 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 pathway for Load Line 4 is to southeast via the stream exiting the large settling pond. This stream exits the AOC along the southern boundary, and, subsequently, flows off of the installation via Parshall flume (PF)-8 (Figure 1-5). The far eastern portion of the AOC drains to the east via drainage ditches that have only intermittent flow; however, these were also identified as potential accumulation points for contaminants. Previous Phase I RI sampling of settling pond sediment showed no detectable quantities of TNT or other explosives. Low levels of TNT were present in the main stream outlet south of the settling pond and upstream of the AOC at the western AOC boundary. Arsenic, cadmium, chromium, lead, and zinc were detected in settling pond sediments and drainage ditch sediments, with the highest levels present in the pond. Based on available data and the CSM, these water bodies and drainage ditches 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 is 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. Accordingly, the main stream, settling pond, and drainage ditches near several former process buildings 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 4. 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 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 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 Line 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 4. These sewer systems may represent accumulation points for contaminants introduced through building floor drains and sink drains during Load Line 4 operations. Reconnaissance of the AOCs during the spring of 2001 indicated that some of the storm and sanitary sewer systems were dry and above the water table; however, several of the storm sewers contained standing or flowing water indicating groundwater influx. 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 U. S. Environmental Protection Agency (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 4. Chapter 2.0 describes the environmental setting at RVAAP and Load Line 4, 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 4. 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 recommendations for future actions. 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 4 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); 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 SERA (Appendixes Q and R, respectively); and USACE radiological survey (Appendix S).

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