2. ENVIRONMENTAL SETTING

This chapter describes the physical characteristics of the LL 1 and the surrounding environment that are factors in understanding the potential contaminant transport pathways, receptors, and exposure scenarios for human health and ecological risks. The geology, hydrology, climate, and ecological characteristics of RVAAP were originally presented in Chapter 3.0 of *the Phase I Remedial Investigation Report for 11 High-Priority Sites at RVAAP* (USACE 1998). Site-specific data from the Phase II RI, as well as local and regional information, are used to refine the CSM of LL 1, which is outlined at the end of this section and presented in detail in Chapter 8.0.

2.1 RAVENNA ARMY AMMUNITION PLANT PHYSIOGRAPHIC SETTING

RVAAP is located within the Southern New York Section of the Appalachian Plateau physiographic province (USGS 1968). This province is characterized by elevated uplands underlain primarily by Mississippian- and Pennsylvanian-age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography with incised streams having dendritic drainage patterns. The Southern New York Section has been modified by glaciation, which rounded ridges, filled major valleys, and blanketed many areas with glacially derived unconsolidated deposits (e.g., sand, gravel, and finer-grained outwash deposits). As a result of glacial activity in this section, old stream drainage patterns were disrupted in many locales, and extensive wetland areas developed.

2.2 SURFACE FEATURES AND SITE TOPOGRAPHY

LL 1 is situated in the southeastern corner of the RVAAP facility, as shown in Figure 1-2. The AOC is characterized by moderately subdued topography on a reworked sandstone bedrock surface. It is surrounded by woodland and is less than 1 mile from the installation's southern and eastern boundaries.

Site elevations vary from approximately 12.2 m (40 ft) across the AOC, from 309.6 m (1,016 ft) above mean sea level (amsl) relative to the National American Vertical Datum of 1988 (NAVD88) near the main entrance to 297.2 m (975 ft) amsl near the east perimeter fence. Inside the production area, the ground surface is hummocky as a result of the extensive excavation of bedrock to accommodate the load line's buildings and infrastructure. Outside the production area and to the southeast, the terrain slopes more uniformly southeastward, with elevations ranging from 298.7 m (980 ft) amsl at the railroad track to 285.9 m (938 ft) amsl at the perimeter fence. This smoother topography reflects the presence of glacial sedimentary cover that has been relatively undisturbed throughout RVAAP's active life (see Figure 1-4).

Cultural features at LL 1 currently consist of two intact buildings (CB-13 and CB-801), floor slabs from the previously demolished buildings (elevated above grade), intact walkways and roadways, storm and sanitary sewer lines, other deactivated utilities, catch basins, manholes, and other drainage features (see Figure 1-6). Although rails and rail ties have been removed, the rail beds of the two main tracks that traverse the site from north to south are still present, with their ballast of industrial slag.

2.3 SOILS AND GEOLOGY

2.3.1 Regional Geology

2.3.1.1 Soils and glacial deposits

Bedrock at RVAAP is overlain by deposits of the Wisconsin-aged Lavery Till in the western portion of the facility and by the younger Hiram Till and associated outwash deposits in the eastern portion (Figure 2-1) (ODNR 1982). Unconsolidated glacial deposits vary considerably in their character and thickness across RVAAP.

Thin coverings of glacial materials have been completely removed as a consequence of human activities at locations such as Ramsdell Quarry, and bedrock is exposed at, or is present near, the ground surface in many locations at LL 1 (USACE 1999a). Where glacial materials are still present, their distribution and character indicate their origin in ground moraine. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts with sand and rock fragments. Deposits from bodies of glacial-age standing water may also have been encountered in the form of >15-m (50-ft)-thick deposits of uniformly light gray silt (USACE 1999a). At a Phase I monitoring well boring on the south end of LL 1 (LL1-066), a fine, saturated gray silt was encountered from a depth of approximately 3 to 9.7 m (10 to 32 ft) below ground surface (bgs) before drilling was terminated. At monitoring wells LL2-059 and LL2-060, glacial deposits on top of bedrock were less than 2.4 m (8 ft) thick.

Soils at RVAAP are generally derived from the Wisconsin-age silty clay glacial till. Distributions of soil types are discussed and mapped in the Soil Survey of Portage County, Ohio (USDA 1978). Much of the native soil present at RVAAP has been reworked or removed during construction activities in operational areas of the installation. According to the Portage County soil survey, the major soil types found in the high-priority AOCs are silt or clay loams with permeabilities ranging from 6.0×10^{-7} to 1.4×10^{-3} cm/s. Additional geotechnical data collected during the Phase II RI can be found in the geotechnical report (Appendix K).

2.3.1.2 Bedrock stratigraphy

The Sharon Member of the Pennsylvanian Pottsville Formation unconformably overlies the eroded Cuyahoga Formation throughout the eastern half of RVAAP. The Sharon Member consists of two units: a lower sandstone unit and an upper shale unit. The Sharon Conglomerate unit of the Sharon Member is highly porous, permeable, cross-bedded, and frequently fractured and weathered. It is present beneath the glacial cover at many locations at RVAAP, including Ramsdell Quarry Landfill and LL 1. The Sharon Shale is light to dark gray, fissile, and has been eroded in many locations. It has not been encountered in investigations of AOCs near LL 1.

2.3.2 Geologic Setting of Load Line 1

2.3.2.1 Soils

At LL 1, soil cover is very thin to nonexistent in the vicinity of Buildings CB-4, CB-4A, CA-6, CA-6A, and CB-14; as these buildings were constructed on excavated bedrock. The presence of soils greater than 0.15 m (0.5 ft) in thickness is observed at locations where fill material was brought in or reworked during either the active life of the load line or during demolition.

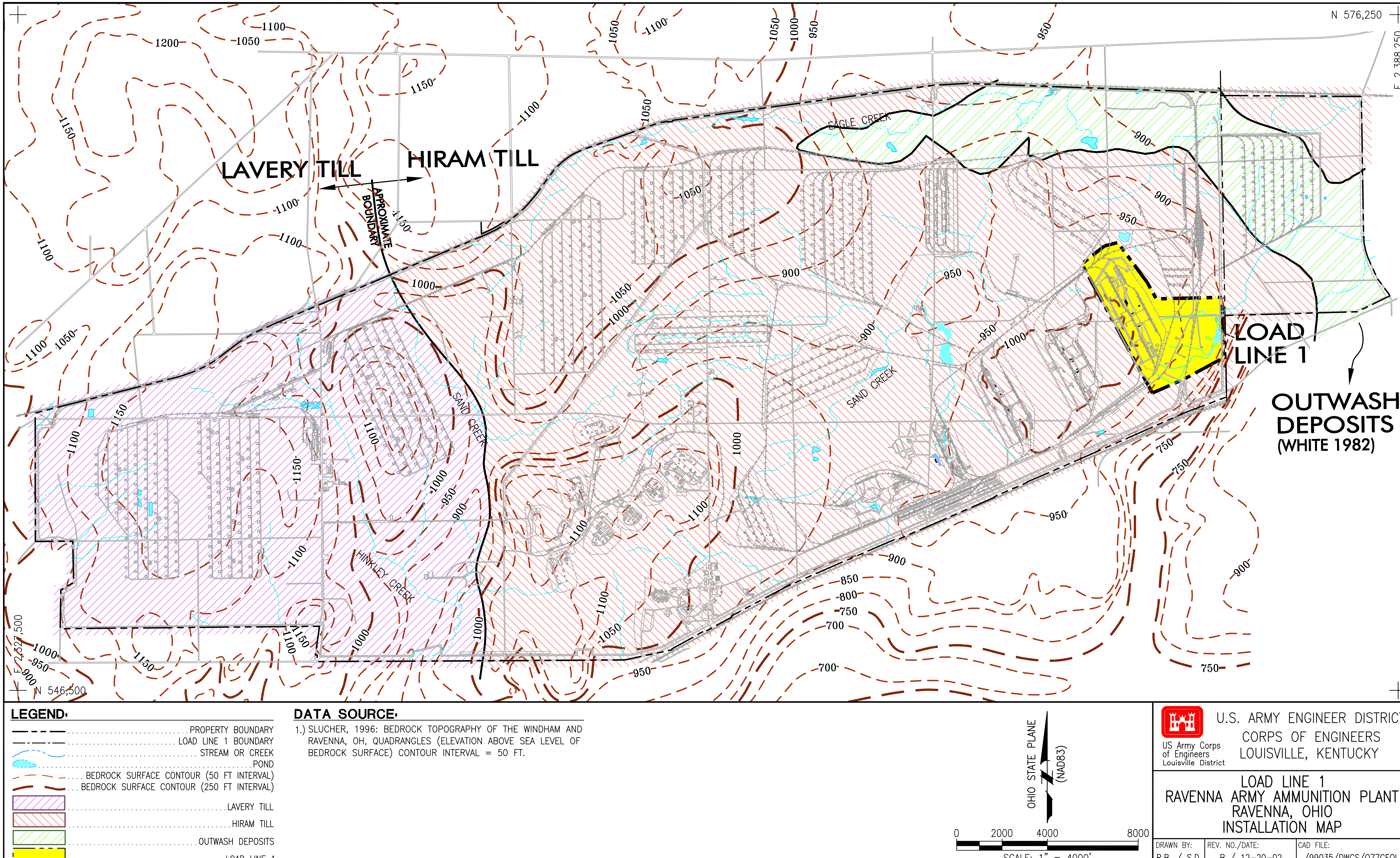

Figure 2-1. Geologic Map of Unconsolidated Deposits on RVAAP, Superimposed on Bedrock Surface Map

Native soils in the vicinity of LL 1 belong to the Mahoning silt loam series, which is one of the five major soil types found within the RVAAP facility. Detailed information on the geotechnical properties of soils from LL 1 is provided in Appendix K.

2.3.2.2 Bedrock geology

The Sharon Conglomerate is exposed at the ground surface throughout LL 1. Notably, the former change houses (CB-23, CB-22, CB-12, and CB-8), the melt-pour buildings (CB-4 and CB-4A) and associated walkways to the change houses, Building CB-14, and railroad Track CB are constructed on bedrock that was excavated to accommodate these structures. Monitoring wells drilled for the Phase II RI were all completed in the Sharon Conglomerate. Therefore, it is presumed that the thickness of the sandstone bedrock at LL 1 exceeds 12.2 m (40 ft). The Sharon Conglomerate was encountered in all Phase I and Phase II monitoring wells installed inside the production area of LL 1 and in the subsurface at monitoring wells south of LL 2.

2.4 HYDROLOGY

2.4.1 Local Hydrogeology

2.4.1.1 Aquifer characteristics

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County as described in the *Phase I Remedial Investigation Report for 11 High-Priority Sites at RVAAP* (USACE 1998). Generally, these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies. However, they are sufficient for residential water supplies. Lateral continuity of these aquifers is not known. Recharge of these units comes from surface water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge areas at RVAAP have not been delineated.

Moderately high horizontal hydraulic conductivities were found in the unconsolidated materials at the south end of LL 1. At LL 1, the slug test performed at LL1mw-064 during the Phase I RI (USACE 1998) revealed a conductivity of 1.7×10^{-3} cm/sec (see Table 2-1). During the Phase II RI, however, none of the wells were completed in unconsolidated material.

Table 2-1. Horizontal Hydraulic Conductivities in Phase I Unconsolidated Monitoring Wells

Monitoring Well ID	Screened Interval (depth bgs, ft)	Total Depth (ft)	Geologic Material Adjacent to Screen	Slug-Test-Determined Hydraulic Conductivity (cm/s)	Laboratory-Determined Hydraulic Conductivity (cm/s)
LL1mw-064	8.02 to 18.02	18.35	Unconsolidated sand	1.7×10^{-3}	[a]

[a]Hydraulic conductivity was not determined for materials from this monitoring well.

2.4.1.2 Bedrock hydrogeology

The sandstones of the Sharon Member, and in particular the Sharon Conglomerate, were the primary sources of groundwater during RVAAP's active phase, although some wells were completed in the Sharon Shale. Past studies of the Sharon Conglomerate indicate that the highest yields come from the true quartz-pebble conglomerate facies and from jointed and fractured zones. Where it is present, the overlying Sharon Shale acts as a relatively impermeable confining layer for the sandstone. Monitoring wells completed in the Sharon Conglomerate at LL 1 in 1999 typically had hydraulic conductivities of 2.35×10^{-5} to 7.3×10^{-4} cm/s (see Table 2-2). No LL 1 wells were completed in the Sharon Shale, but wells in other areas of RVAAP completed in the Sharon Shale generally exhibit much lower hydraulic conductivities than those in the sandstone.

Table 2-2. Horizontal Hydraulic Conductivities in Phase I and Phase II RI Bedrock Monitoring Wells

Monitoring Well ID	Screened Interval (depth bgs, ft)	Total Depth (ft)	Geologic Material Adjacent to Screen	Slug-Test-Determined Hydraulic Conductivity (cm/s)[a]	Laboratory-Determined Hydraulic Conductivity (cm/s)
LL2mw-059	9.14 to 19.14	19.50	Sharon Sandstone	9.8×10^{-5}	[b]
LL2mw-060	8.08 to 17.94	18.30	Sharon Sandstone	5.7×10^{-4}	[b]
LL1mw-063	17.1 to 27.1	27.40	Sharon Sandstone	2.35×10^{-5}	[b]
LL1mw-067	12.77 to 22.8	22.80	Sharon Sandstone	6.5×10^{-5}	[b]
LL1mw-078	28.73 to 38.70	38.70	Sharon Sandstone	3.5×10^{-5}	[b]
LL1mw-079	29.53 to 38.93	39.46	Sharon Sandstone	9.8×10^{-5}	[b]
LL1mw-080	9.50 to 18.97	19.47	Sharon Sandstone	3.5×10^{-4}	[b]
LL1mw-081	29.38 to 38.85	39.35	Sharon Sandstone	4.5×10^{-5}	1.20E-4[c]
LL1mw-082	28.90 to 38.90	39.02	Sharon Sandstone	6.5×10^{-5}	3.40E-4[c]
LL1mw-083	29.07 to 39.07	39.30	Sharon Sandstone	5.0×10^{-4}	[b]
LL1mw-084	26.73 to 36.28	36.96	Sharon Sandstone	7.3×10^{-4}	[b]
LL1mw-085	32.17 to 41.64	42.14	Sharon Sandstone	7.0×10^{-4}	[b]

[a]The saturated thickness used to calculate Re/rw for each specific slug test analysis (Bouwer and Ricer) was estimated as 5 ft greater than the total depth of the well.
[b]Hydraulic conductivity was not determined for materials from this monitoring well.
[c]Hydraulic conductivity was determined as part of the geotechnical analysis (Appendix K).
RI = remedial investigation.

Potentiometric surface maps of LL 1 are provided in Figures 2-2 and 2-3. The contours presented on these figures are based on water levels collected during groundwater sampling in September 1999 and September 2000, respectively. A potentiometric high exists in the vicinity of Building CB-4A, centered around well LL1-080, corresponding to a topographic high that exceeds 1,020 amsl. Potentiometric contours indicate radial flow away from this high and a potentiometric surface that is a subdued replica of the regional topography. Overall flow directions across the site are easterly with northeasterly and southeasterly components in the northern and southern half of the load line, respectively.

2.4.1.3 Surface water hydrology

As shown on Figure 1-6, effluent and runoff from the main production area exited through ditches and storm sewers to discharge points along the perimeter of the load line identified as Outlets A, B, C, D, E, and F. An undesignated discharge point lies in the northwestern corner of the load line and receives drainage from the northern portions of LL 1 (North Area Channel for purposes of this report). Outlet A received settling tank effluent and storm sewer discharges from the northern point of LL 1, and flowed northeast to the confluence with the Outlet B channel. From the confluence of the Outlets A and B channels, flow continued in a drainage channel northeast until merging with an unnamed tributary that feeds the Outlet C channel and Charlie's Pond. Outlets C, D, E, and F received runoff and storm sewer discharges from the central and southern points of the load line. Outlet C discharges into Charlie's Pond.

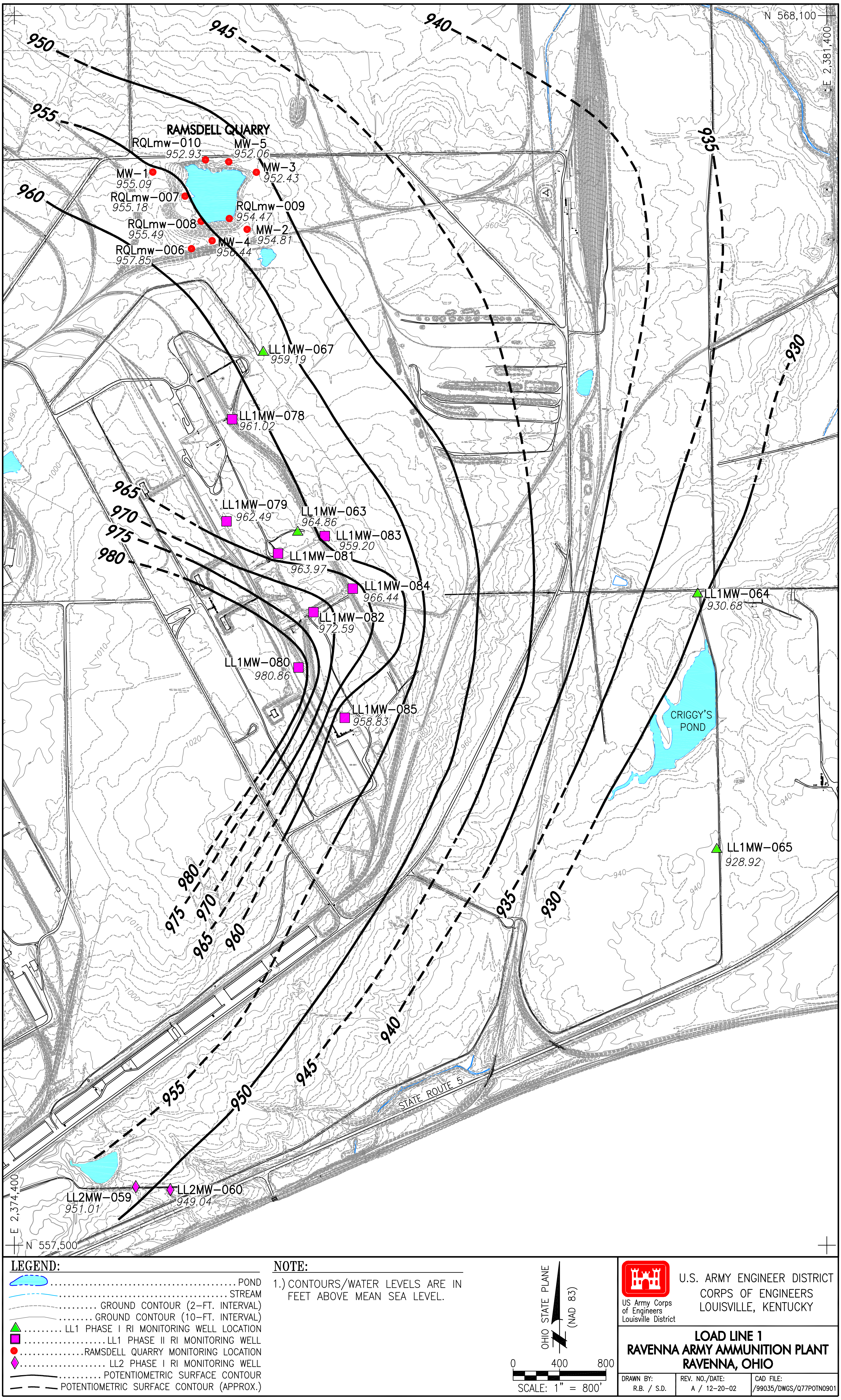

Figure 2-2. Potentiometric Map of Load Line 1 and Vicinity, Conditions on September 5, 2000

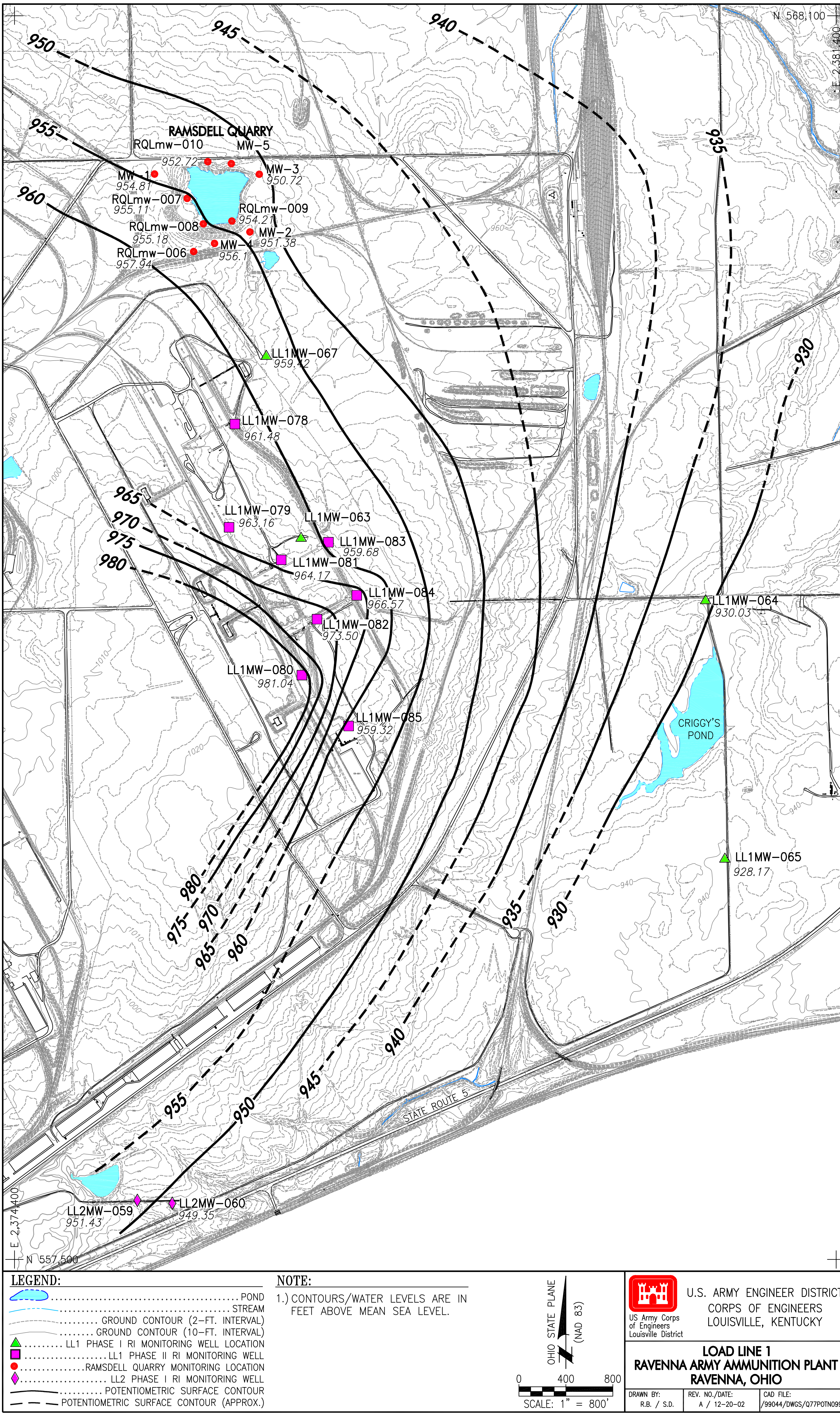

Figure 2-3. Potentiometric Map of Load Line 1 and Vicinity, Conditions on September 8, 1999

Outlets D, E, and F discharge into Criggy's Pond (Figure 2-4). Outflow from Charlie's and Criggy's Pond merge and ultimately exit RVAAP at PF534. The drainage basin that discharges through PF534 also receives runoff from other potential contaminant sources in the easternmost part of RVAAP [e.g., Erie Burning Grounds (EBG), Ore Piles, multiple rail beds].

Figure 2-4. Conditions at Criggy's Pond during Phase II RI Sampling

2.5 CLIMATE

RVAAP has a humid continental climate characterized by warm, humid summers and cold winters. Precipitation varies widely throughout the year. The average driest month is February, and the wettest month is July. Data from the National Weather Service compiled over the past 47 years indicate that the average rainfall for the area is 0.98 m (38.72 in.) annually. The average snowfall is 1.1 m (43.4 in.) annually. Severe weather, in the form of thunder, hail, or snow storms, is common during the summer and winter. Tornadoes are infrequent in Portage County.

2.6 POTENTIAL RECEPTORS

2.6.1 Human Receptors

RVAAP consists of 8,998.3 hectares (21,419 acres) and is located in northeastern Ohio, approximately 37 km (23 miles) east-northeast of Akron and 48.3 km (30 miles) west-northwest of Youngstown. RVAAP occupies east-central Portage County and southwestern Trumbull County. The 2000 Census lists the total populations of Portage and Trumbull counties at 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 farm acreage. The Michael J. Kirwan Reservoir (also known as West Branch Reservoir) is the closest major recreational area and is adjacent to the western half of RVAAP south of State Route 5.

LL 1 is located in the southeastern corner of RVAAP and is not currently used for OHARNG training activities. Since the completion of demolition activities at the load line, industrial workers do not frequent the area. Load lines at RVAAP are used for yearly deer hunts held on Saturdays in October and November. Recently, the OHARNG reinstituted a limited catch-and-release fishing program for employees at several ponds at RVAAP, including Criggy's Pond (OHARNG 2001a). Security activities consist of gate checks and surveillance along LL 1 Road. Expected future land use of LL 1 is as a training area for the OHARNG.

2.6.2 Ecological Receptors

Dominant vegetative cover types at RVAAP, including LL 1's immediate surroundings, are forests and old fields of various ages. More than 80% of RVAAP is now in forest. Most of the old field cover is the result of earlier agricultural practices that left these sites with poor topsoil, which limits forest regeneration. Several thousand acres of agricultural fields were planted in trees during the 1950s and 1960s, but these plantings were not successful in areas with poor topsoil. Some fields, leased for cattle grazing during the same time period, were delayed in their reversion of forest. A few fields have been periodically mowed, maintaining them as old field.

From one-half to two-thirds [4,046 to 6,070 hectares (10,000 to 15,000 acres)] of RVAAP's land area meets the regulatory definition of jurisdictional wetland. Wetland areas at RVAAP include seasonally saturated wetlands, wet fields, and forested wetlands. Most of these wetlands exist because of the presence of poorly drained and hydric soils. Beaver impoundments contribute to wetland diversification on the site, as at EBG to the north of LL 1.

The flora and fauna present at RVAAP are varied and widespread. A listing of state endangered, state threatened or potentially threatened, and state special interest species confirmed to be on RVAAP is provided on Table 2-3 (Morgan 2000). Additionally, five rare plant communities/significant natural areas have been identified on RVAAP, including the northern woods, Wadsworth Glen, Group 3 woods, B&O Wye Road area, and south Patrol Road swamp forest.

Restricted land use and sound forest management practices have preserved and enabled large forest tracts to mature. Habitat conversion at RVAAP, unlike most other areas of the country that are clearing forests for agricultural use, has been towards restoration of forested areas. The reversion of these agricultural fields to mature forest provides a diversity of habitats from old field through several successional stages. Overall, the trend toward forest cover enhances the area for use by both plant and animal forest species. Future IRP activities will require consideration of these species to ensure that detrimental effects on threatened or endangered RVAAP flora and fauna do not occur. This will be discussed in the Ecological Risk Assessment presented in Chapter 7.0. There are no federal, state, or local parks or protected areas on RVAAP facility property.

Table 2-3. RVAAP Rare Species List as of April 19, 2000

A. State Endangered
   1. Northern harrier, *Circus cyaneus*
   2. Common barn owl, *Tyto alba*
   3. Yellow-bellied sapsucker, *Sphyrapicus varius*
   4. Mountain brook lamprey, *Ichthyomyzon greeleyi*
   5. Graceful underwing, *Catocala gracilis*
   6. Ovate spikerush, *Eleocharis ovata* (Blunt spike-rush)
   7. Lurking leskea, *Plagiothecium latebricola*
   8. Northern river otter, *Lutra canadensis*
   9. Little blue heron, *Egretta caerulea* (suspected)
   10. American bittern, *Botaurus lentiginosu* (migrant)
   11. Canada warbler, *Wilsonia canadensis* (migrant)
   12. Osprey, *Junco hyemalis* (migrant)
   13. Trumpeter swan, *Cygnus buccinator* (migrant)
   14. Little blue heron, *Egretta caerulea* (migrant)

B. State Threatened
   1. Simple willow-herb, *Epilobium strictum*

C. State Potentially Threatened
   1. Gray birch, *Betula populifolia*
   2. Round-leaved sundew, *Drosera rotundifolia*
   3. Closed gentian, *Gentiana clausa*
   4. Butternut, *Juglans cinerea*
   5. Blunt mountain-mint, *Pycnanthemum muticum*
   6. Northern rose azalea, *Rhododendron nudiflorum* var. *roseum*
   7. Large cranberry, *Vaccinium macrocarpon*
   8. Hobblebush, *Viburnum alnifolium*
   9. Long beech fern, *Phegopteris connectilis*
   10. Woodland horsetail, *Equisetum sylvaticum*
   11. Weak sedge, *Carex debilis* var. *debilis*
   12. Straw sedge, *Carex straminea*
   13. Water avens, *Geum rivale*
   14. Tall St. John's wort, *Hypercium majus*
   15. Swamp oats, *Sphenopholis pensylvanica*
   16. Shining ladies'-tresses, *Spiranthes lucida*

D. State Special Interest
   1. Sora, *Porzana carolina*
   2. Virginia rail, *Rallus limicola*
   3. Four-toed salamander, *Hemidactylium scutatum*
   4. Smooth green snake, *Opheodrys vernalis*
   5. Woodland jumping mouse, *Napaeozapus insignis*
   6. Sharp-shinned hawk, *Accipiter striatus*
   7. Solitary vireo, *Vireo solitarius*
   8. Pygmy shrew, *Sorex hoyi*
   9. Star-nosed mole, *Condylura cristata*
   10. Red-shouldered hawk, *Buteo lineatus*
   11. Henslow's sparrow, *Ammodramus henslowii*
   12. Cerulean warbler, *Dendroica cerulea*
   13. Common moorhen, *Gallinula chloropus*
   14. Eastern box turtle, *Carolina carolina*
   15. *Capperia evansi* (moth)
   16. *Zanclognatha martha* (moth)
   17. *Oligia bridghami* (moth)
   18. *Chaetaglaea sericea* (moth)
   19. *Sutyna privata* (moth)
   20. *Homorthodes frufurata* (moth)

Source: Morgan (2000).
RVAAP = Ravenna Army Ammunition Plant.

2.7 CONCEPTUAL SITE MODEL

Information gathered during the Phase I and Phase II RIs has been used to develop a general CSM for LL 1. This is further developed in Chapter 5.0 of this RI report with the evaluation of contaminant fate and transport modeling. The elements of the general CSM are as follows:

- The topography at LL 1 is moderately subdued, with elevations ranging from 297.2 to 309.6 m (975 to 1,016 ft) amsl in the production area. The topography is the result of the reworking of the original glaciated bedrock surface to accommodate the buildings and other infrastructure of LL 1. Topographic relief southeast of the main load line varies from 285.9 to 298.7 m (938 to 980 ft) amsl, where glacial cover is present. The thickness of glacial material varies in this area from 2.1 to >10.7 m (7.7 to > 35 ft).

- Soil cover is thin to nonexistent at many locations inside the main production area at LL 1, except where non-native material was brought in during construction of RVAAP or was redistributed during the demolition of buildings at the load line. Bedrock is exposed at locations throughout the production area. A thicker soil covers the glacial materials southeast of the main load line. Surface soils contain contaminants in the highest concentrations at the melt-pour buildings (CB-4 and CB-4A), Building CB-10, the former settling tanks, and near Building CA-6. Lead, cadmium, and zinc were commonly detected in Phase I soils. Organic compounds were present in 9 of 12 Phase I samples, including several PAHs and PCBs/pesticides.

- Groundwater is present in the sandy interbeds found in glacial materials that occur south of the load line proper, at depths from about 4.26 to 4.57 m (14 to 15 ft) bgs. This glacial material exceeds 10.6 m (35 ft) in thickness in some locations. The water-bearing sand units may be laterally discontinuous. It is not known whether the two wells installed in the Phase I RI in glacial materials are in hydraulic communication with one another. Groundwater in the production area of LL 1 occurs in the highly porous, permeable, and fractured Sharon Conglomerate. It is presumed that these wells have some degree of hydraulic communication. Based on the site's topography and potentiometric surface data from the nine monitoring wells within the production area groundwater flows to the north and east from a groundwater divide located just south of the melt-pour complex (Figure 2-2). The water-bearing sandstone behaves as an unconfined system.

- Surface water from precipitation collects in storm water catch basins and unlined ditches throughout the production area. Such runoff is discharged through two exit pathways: The north outlet that drains into Sand Creek, and all other outlets that drain into the unnamed creek exiting RVAAP at State Route 534. Water levels at the pond may vary by several in. in response to seasonal variations in precipitation.

- The potential for human exposure to any contaminants migrating from LL 1 is mitigated by the lack of permanent residents on RVAAP and the low population density on adjacent private properties. No signs of ecological stress in the indigenous populations were noted during the field investigation.

Contaminant sources at LL 1 are the individual buildings within the production areas (specifically CB-4, CB-4A, CA-6, CA-6A, CB-10, CA-17, CB-13, and CB-14) and the former settling tanks located north of Building CB-3 and northwest of Building CA-6. The buildings were used to supply, melt, pour, load, and mill explosives for munitions processing. Buildings CB-13 and CB-10 were later reused for demilitarization operations. Explosive residues are present in the soils surrounding these buildings. Precipitation or recent demolition activities may have caused these contaminants to migrate into subsurface soils and to groundwater. The crushed slag that was used throughout RVAAP for roads, railroad beds, and driveways may also be a source of aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, magnesium, and zinc contamination. Contaminants released from LL 1 sources include metals, explosives, propellants, and SVOCs.