3.0 STUDY AREA INVESTIGATION

This chapter presents information on sampling locations and the rationale for samples collected during the field effort, and provides a synopsis of the sampling methods employed during the investigation. Specific notation is made where site conditions required a departure from planned activities in the Phase II RI SAP Addendum (USACE 2001b). Information regarding standard field decontamination procedures, sample container types, preservation techniques, sample labeling, chain-of-custody, and packaging and shipping requirements implemented during the field investigation may be found in the Facility-wide SAP (USACE 2001c) and the Phase II RI SAP Addendum (USACE 2001b).

The scope of the Phase II RI field effort at Load Line 4 included sampling of surface and subsurface soils, debris, sediment, surface water, and groundwater. Other investigative activities included excavation of 6 test trenches to depths of 4.6 m (14 ft) to characterize soil stratigraphy, biased floor sweep samples from 3 buildings, sampling beneath building floors, a video camera survey of portions of the former sanitary sewer system, and sampling of surface water and sediment from the former sanitary sewer system. In addition, analyses for TNT and RDX using a colorimetric method were performed in a field-based laboratory to provide an indication of contamination nature and extent and to help guide the sampling efforts.

In order to organize and track sampling efforts, the AOC was separated into 26 functional areas in the Phase II RI SAP Addendum based on: (1) type of environmental media (i.e., soil, surface water, or groundwater), (2) DQOs, (3) historical operational data, (4) available Phase I RI data, and (5) site characteristics. These functional areas and a summary of the environmental matrices that were sampled within each are listed in Table 3-1.

Functional areas 1 through 20 include former operational facilities and physical plant structures. Functional areas 21, 22, and 23 address soils in non-production areas and surface water and sediment downstream of the AOC. Functional areas 24 and 25 are the storm and sanitary sewer systems; functional area 26 is groundwater. The rationale and approach for sampling within these functional areas was based on the project DQOs, as discussed in Section 1.4.

3.1 SOIL AND VADOSE ZONE CHARACTERIZATION

One hundred two soil samples for chemical analyses were collected from a total of 95 stations located throughout Load Line 4. Samples were collected from surface and subsurface locations, as well as from test pits (perimeter trenches) and beneath building floor slabs. Although not considered a soil matrix, three floor sweep samples of debris from within primary operations buildings (G-19, G-8, and G-3) were collected and submitted for chemical analysis and are addressed in this section. Figures 3-1 through 3-3 illustrate the locations for surface soil and subsurface soil sampling. Table 3-2 provides a detailed listing of the soil and related samples described above that were collected during the Phase II RI field effort. Departures from the planned sampling efforts due to site conditions (i.e., refusal), additional analyses added during the field effort, and the locations of contingency samples are specifically denoted.

3.1.1 Rationale

Data from soil samples collected during the Phase II RI at Load Line 4 were obtained to identify areas contaminated as a result of historical site operations and to determine the vertical and horizontal extent of identified contamination. Soil sampling data were also obtained to evaluate the potential for contaminant migration via leaching or erosional processes from surface soil sources to receptor media, such as sediment and surface water, using numerical models and qualitative methods (see Chapter 5.0). The

Table 3-1. Load Line 4 Sampling Rationale and Matrix

Functional Area Number	Description	Principal Suspected Contaminants	Sampling Rationale	Sample Matrix		
				Soil Station	Sediment/ Surface Water Station	Monitoring Well Boring/ Groundwater Station
1	Building WW-23 – Water Tower	Metals	Identify possible contamination in soil	•		
2	Building G-16 – Explosives Receiving	Explosives and metals	Identify possible contamination in soil	•		
3	Building G-9 – Magazine/Empty Cart	Explosives and metals	Define the extent of contamination outside of the building floor slab in soil and obtain soil data from beneath the floor slab	•		
4	Building G-11– Explosive Preparation	Explosives and metals	Identify possible contamination in soil	•		
5	Building G-1– Material Receiving	Explosives and metals	Identify possible contamination in soil	•		
6	Building G-1A – Explosive Preparation	Explosives and metals	Identify possible contamination in soil	•		
7	Building G-5 – Service Building	Explosives and metals	Identify possible contamination in soil	•		
8	Building G-18 – Packing And Shipping	Explosives and metals	Identify possible contamination in soil	•		
9	Building G-19 – Service Building	Explosives and metals	Identify possible contamination in soil	•		
10	Building G-19A – Service Building	Explosives and metals	Identify possible contamination in soil	•		
11	Building G-15 – Explosive Preparation	Explosives and metals	Define the extent of contamination outside of the building floor slab in soil and obtain soil data from beneath the floor slab	•		
12	Building G-13 – Funnel Removal and Face Off	Explosives and metals	Identify possible contamination in soil	•		
13	Building G-12A – Explosives Cooling	Explosives and metals	Identify possible contamination in soil	•		
14	Settling Tank	Explosives and metals	Define extent of contamination in soil	•		
15	Building G-10 – Explosive Preparation	Explosives and metals	Define the extent of contamination outside of the building floor slab in soil and obtain soil data from beneath the floor slab	•		
16	Building G-8 – Melt-Pour Building	Explosives, SVOCs, VOCs, metals, and PCBs	Define the extent of contamination outside of the building floor slab in soil and obtain soil data from beneath the floor slab	•	•	
17	Building G-3 – Inert Storage	Explosives and metals	Identify possible contamination in soil	•		

Table 3-1. Load Line 4 Sampling Rationale and Matrix (continued)

Functional Area Number	Description	Principal Suspected Contaminants	Sampling Rationale	Sample Matrix		
				Soil Station	Sediment/ Surface Water Station	Monitoring Well Boring/ Groundwater Station
18	Building G-4 – Boiler House	Explosives, SVOCs, VOCs, metals, and PCBs	Define the extent of contamination outside of the building floor slab in soil and obtain soil data from beneath the floor slab	•		
19	Building G-6 – Change House	Explosives and metals	Identify possible contamination in soil	•		
20	Building G-6A – Change House	Explosives and metals	Identify possible contamination in soil	•		
21	Non-Production Area (Random Sampling Grid)	Explosives and metals	Statistically representative characterization of non-production areas (Phase I RI sample data from stations 041, 042, and 043 to be used to represent additional grid points)	•		
NA	Contingency Samples	TBD	To be assigned in the field	•		
22	Test Pits	Geotechnical	To provide a better understanding of the flow regime and to assist in selecting optimal locations for monitoring wells	•		
23	AOC Ditches, Streams, and Ponds	All; Full analytical suite performed	Characterize potential contaminant exit pathways and accumulation points		•	
24	Storm Sewer System	All; Full analytical suite performed	Characterize potential contaminant exit pathways and accumulation points		•	
25	Sanitary Sewer System	All; Full analytical suite performed	Characterize potential contaminant exit pathways and accumulation points		•	
26	Additional Monitoring Wells	All; Full analytical suite performed	Identify possible contamination in groundwater near source areas			•
			Identify possible contamination in groundwater and potential off-AOC transport of contamination to the south			•

* One sample of residual debris (soil, paint chips, etc.) from the building floor will be collected.
Full suite = Explosives, Target Analyte List (TAL) metals, cyanide, VOCs, SVOCs, and PCBs/Pesticides.
AOC = Area of Concern.
NA = Not applicable.
PCB = Polychlorinated biphenyl.
SVOC = Semivolatile organic compound.
TBD = To be determined.
VOC = Volatile organic compound.

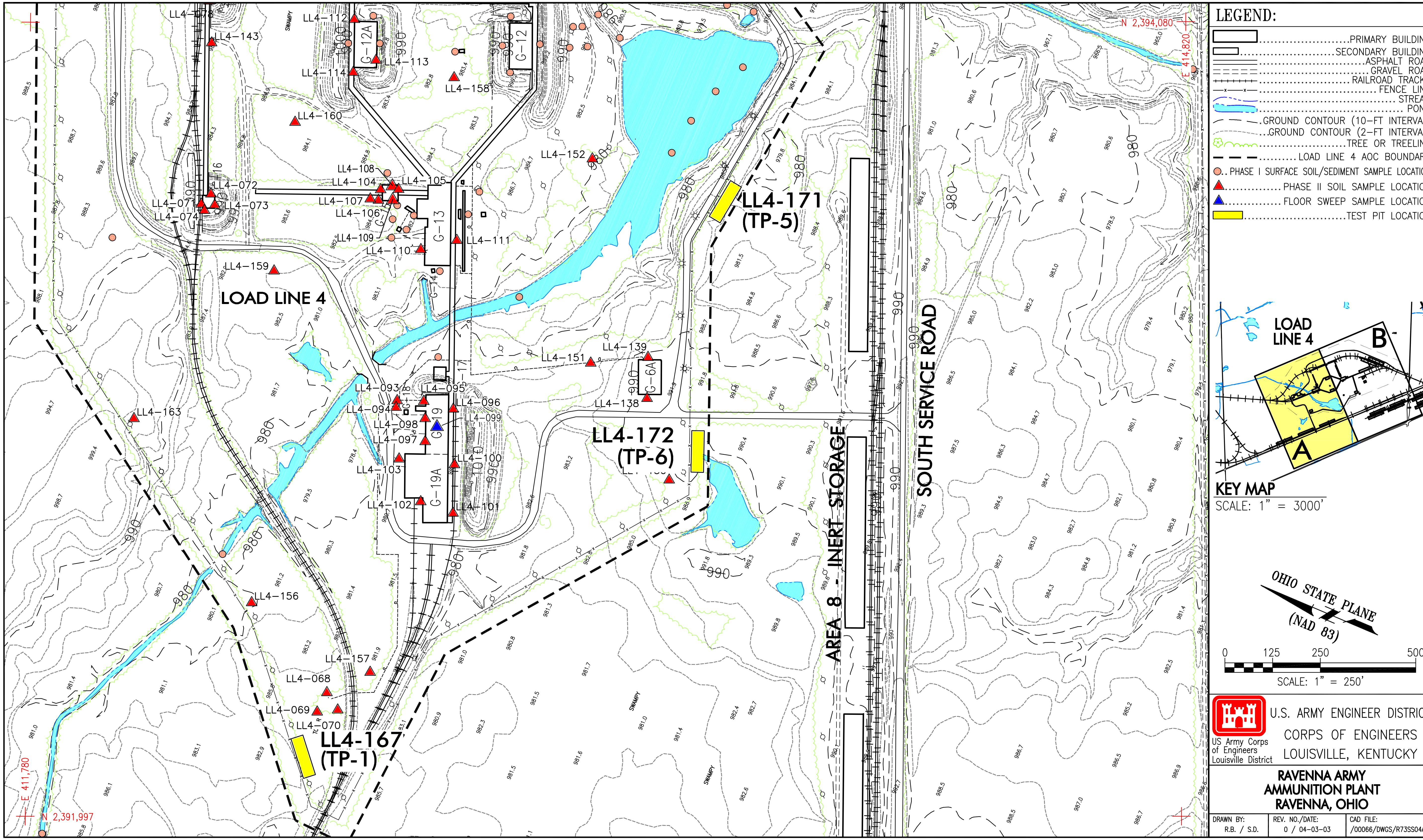

Figure 3-1. Phase II RI Surface and Subsurface Soil Sampling Locations at Load Line 4 - Western Section

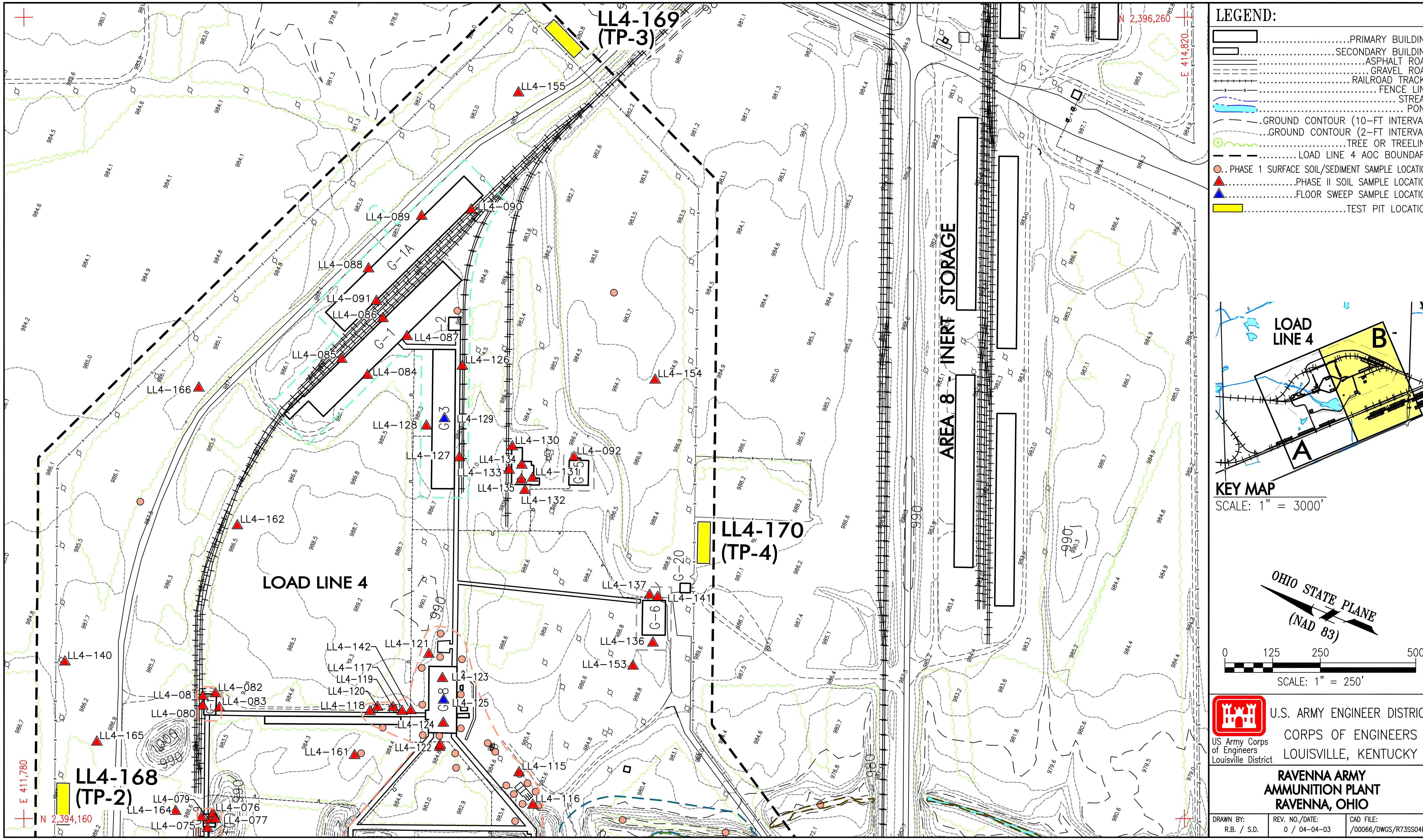

Figure 3-2. Phase II RI Surface and Subsurface Soil Sampling Locations at Load Line 4 - Eastern Section

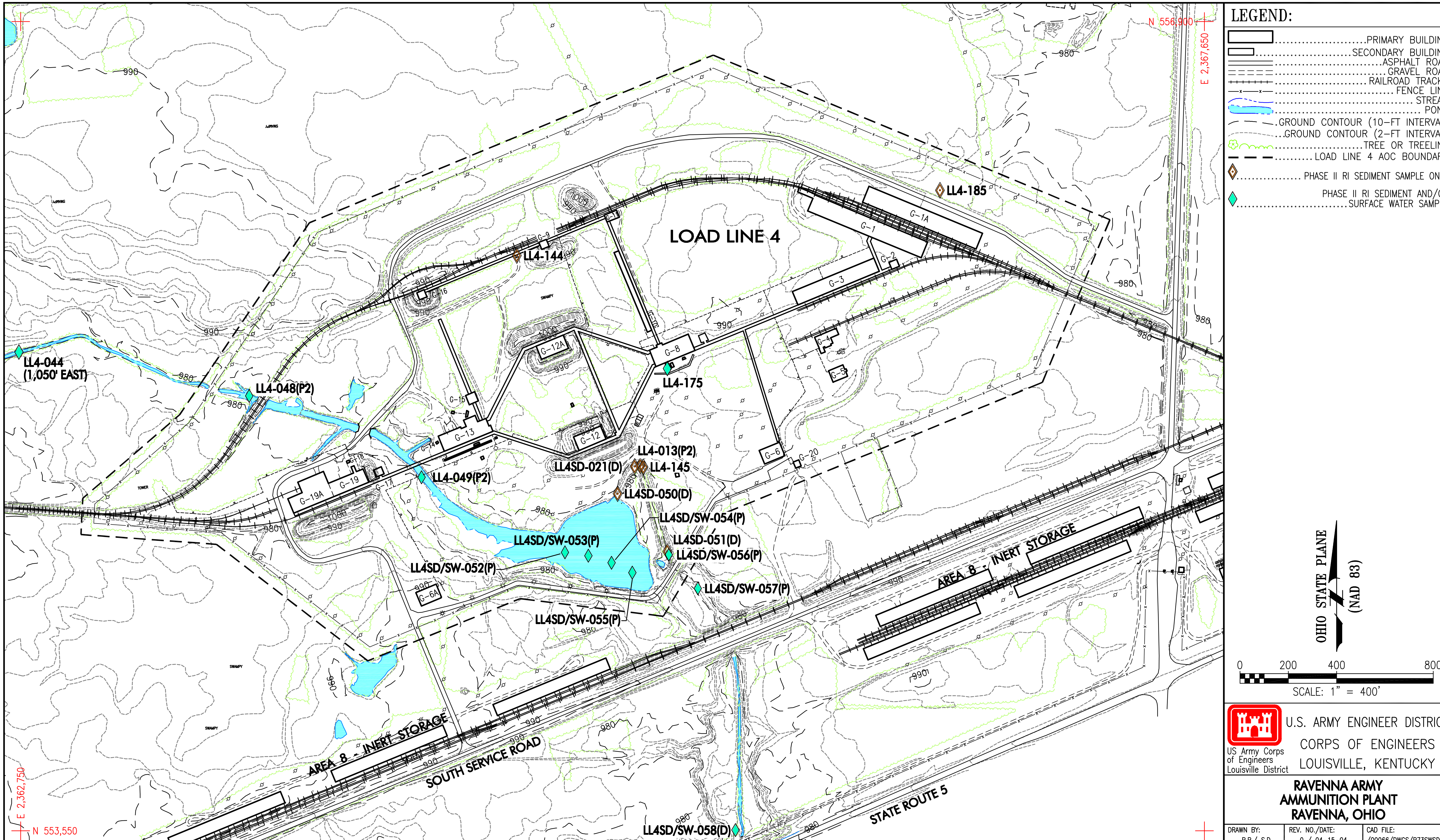

Figure 3-6. Phase II RI Sediment and Surface Water Sampling Locations at Load Line 4

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
WW-23 Water Tower	0 to 1	LL4-068	LL4ss-068-0680-SO	Yes	8/21/01	Propellant sample collected 8/23/02 at 0948; TNT = 1.8 mg/kg
	1 to 3	LL4-068	LL4so-068-0681-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	3 to 5	LL4-068	LL4so-068-0682-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-069	LL4ss-069-0683-SO	Yes	8/21/01	TNT = 1.5 mg/kg
	1 to 3	LL4-069	LL4so-069-0684-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	3 to 5	LL4-069	LL4so-069-0685-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-070	LL4ss-070-0686-SO	Yes	8/21/01	TNT = 2.8 mg/kg
	1 to 3	LL4-070	LL4so-070-0687-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-070	LL4so-070-1151-SO	Yes	8/23/01	Duplicate
	1 to 3	LL4-070	LL4so-070-1169-SO	Yes	8/23/01	Split
	3 to 5	LL4-070	LL4so-070-0688-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
G-16 Explosive Receiving	0 to 1	LL4-071	LL4ss-071-0689-SO	Yes	8/21/01	MC, pH; refusal at 0.7 ft; TNT = 11 mg/kg
	1 to 3	LL4-071	LL4so-071-0690-SO	No		Refusal at 0.7 ft
	3 to 5	LL4-071	LL4so-071-0691-SO	No		Refusal at 0.7 ft
	0 to 1	LL4-072	LL4ss-072-0692-SO	Yes	8/21/01	MC, pH, TNT/RDX < 1 mg/kg
	1 to 3	LL4-072	LL4so-072-0693-SO	No		Field explosives <1 mg/kg in surfacesample
	3 to 5	LL4-072	LL4so-072-0694-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-073	LL4ss-073-0695-SO	Yes	8/21/01	MC, pH; refusal at 0.5 ft; TNT/RDX < 1 mg/kg
	1 to 3	LL4-073	LL4so-073-0696-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-073	LL4so-073-0697-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-074	LL4ss-074-0698-SO	Yes	8/21/01	MC, GS, pH, AL, SG, USCS; TNT/RDX < 1 mg/kg
	0 to 1	LL4-074	LL4ss-074-1148-SO	Yes	8/21/01	Duplicate
	0 to 1	LL4-074	LL4ss-074-1166-SO	Yes	8/21/01	Split
	1 to 3	LL4-074	LL4so-074-0699-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-074	LL4so-074-0700-SO	No		Field explosives <1 mg/kg in surface sample
G-9 Explosive Screening	0 to 1	LL4-075	LL4ss-075-0701-SO	Yes	8/22/01	MC, pH; TNT = 4.14 mg/kg
	1 to 3	LL4-075	LL4so-075-0702-SO	Yes	8/23/01	Refusal at 2 ft; TNT/RDX < 1 mg/kg
	3 to 5	LL4-075	LL4so-075-0703-SO	No		Refusal at 2.0 ft
	0 to 1	LL4-076	LL4ss-076-0704-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	0 to 1	LL4-076	LL4ss-076-1138-SO	Yes	8/22/01	Duplicate
	0 to 1	LL4-076	LL4ss-076-1156-SO	Yes	8/22/01	Split
	1 to 3	LL4-076	LL4so-076-0705-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-076	LL4so-076-0706-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-077	LL4ss-077-0707-SO	Yes	8/22/01	MC, pH; refusal at 1 ft; TNT = 2.14 mg/kg
	1 to 3	LL4-077	LL4so-077-0708-SO	No		Refusal at 1.0 ft
	3 to 5	LL4-077	LL4so-077-0709-SO	No		Refusal at 1.0 ft
	0 to 1	LL4-078	LL4ss-078-0710-SO	Yes	8/22/01	MC, pH; TNT/RDX < 1 mg/kg
	1 to 3	LL4-078	LL4so-078-0711-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-078	LL4so-078-0712-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-079	LL4ss-079-0713-SO	Yes	8/22/01	Subfloor; TNT/RDX < 1 mg/kg
G-11 Magazine/Empty Cart	0 to 1	LL4-080	LL4ss-080-0714-SO	Yes	8/22/01	MC, pH (Geotech sample ID was LL40982 reassigned from station LL4-180); refusal at 1 ft; TNT = 2.98 mg/kg
	1 to 3	LL4-080	LL4so-080-0715-SO	No		Refusal at 1.0 ft
	3 to 5	LL4-080	LL4so-080-0716-SO	No		Refusal at 1.0 ft
	0 to 1	LL4-081	LL4ss-081-0717-SO	Yes	8/22/01	MC, pH; refusal at 0.9 ft; TNT = 1.51 mg/kg
	1 to 3	LL4-081	LL4so-081-0718-SO	No		Refusal at 0.9 ft
	3 to 5	LL4-081	LL4so-081-0719-SO	No		Refusal at 0.9 ft
	0 to 1	LL4-082	LL4ss-082-0720-SO	Yes	8/22/01	MC, pH; refusal at 1.0 ft; TNT/RDX < 1 mg/kg
	1 to 3	LL4-082	LL4so-082-0721-SO	No		Refusal at 1.0 ft
	3 to 5	LL4-082	LL4so-082-0722-SO	No		Refusal at 1.0 ft
	0 to 1	LL4-083	LL4ss-083-0723-SO	Yes	8/22/01	MC, GS, pH, AL, SG, USCS; TNT/RDX < 1 mg/kg
	1 to 3	LL4-083	LL4so-083-0724-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-083	LL4so-083-0725-SO	No		Field explosives <1 mg/kg in surface sample
G-1 Material Receiving	0 to 1	LL4-084	LL4ss-084-0726-SO	Yes	8/24/01	TNT = 5.3 mg/kg
	1 to 3	LL4-084	LL4so-084-0727-SO	Yes	8/25/01	TNT/RDX < 1 mg/kg
	3 to 5	LL4-084	LL4so-084-0728-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-085	LL4ss-085-0729-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-085	LL4so-085-0730-SO	No		Field explosives <1 mg/kg in surface sample

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	3 to 5	LL4-085	LL4so-085-0731-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-086	LL4ss-086-0732-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-086	LL4so-086-0733-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-086	LL4so-086-0734-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-087	LL4ss-087-0735-SO	Yes	8/24/01	TNT = 2 mg/kg
	1 to 3	LL4-087	LL4so-087-0736-SO	Yes	8/25/01	TNT/RDX < 1 mg/kg
	3 to 5	LL4-087	LL4so-087-0737-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
G-1A Material Receiving	0 to 1	LL4-088	LL4ss-088-0738-SO	Yes	8/22/01	Propellant sample collected 8/24/01 at 1523; TNT = 10.3 mg/kg
	1 to 3	LL4-088	LL4so-088-0739-SO	Yes	8/24/01	Refusal at 2.8 ft; TNT/RDX < 1 mg/kg
	3 to 5	LL4-088	LL4so-088-0740-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-089	LL4ss-089-0741-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-089	LL4so-089-0742-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-089	LL4so-089-0743-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-090	LL4ss-090-0744-SO	Yes	8/23/01	Original explosives sample mistakenly not sent to contract laboratory; TNT/RDX < 1 mg/kg
	0 to 1	LL4-090	LL4ss-090-1139-SO	Yes	8/23/01	Duplicate
	0 to 1	LL4-090	LL4ss-090-1157-SO	Yes	8/23/01	Split
	1 to 3	LL4-090	LL4so-090-0745-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-090	LL4so-090-0746-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-091	LL4ss-091-0747-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-091	LL4so-091-0748-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-091	LL4so-091-0749-SO	No		Field explosives <1 mg/kg in surface sample
G-5 Office	0 to 1	LL4-092	LL4ss-092-0750-SO	Yes	8/14/01	Refusal at 0.9 ft; TNT/RDX < 1 mg/kg
	1 to 3	LL4-092	LL4so-092-0751-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-092	LL4so-092-0752-SO	No		Field explosives <1 mg/kg in surface sample
G-18 Packing and Shipping	0 to 1	LL4-093	LL4ss-093-0753-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-093	LL4so-093-0754-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-093	LL4so-093-0755-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-094	LL4ss-094-0756-SO	Yes	8/22/01	Refusal at 0.8 ft; TNT/RDX < 1 mg/kg
	0 to 1	LL4-094	LL4ss-094-1146-SO	Yes	8/22/01	Duplicate

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	0 to 1	LL4-094	LL4ss-094-1164-SO	Yes	8/22/01	Split
	1 to 3	LL4-094	LL4so-094-0757-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-094	LL4so-094-0758-SO	No		Field explosives <1 mg/kg in surface sample
G-19 Packing and Shipping	0 to 1	LL4-095	LL4ss-095-0759-SO	Yes	8/22/01	Refusal at 1 ft; TNT = 7.04 mg/kg
	1 to 3	LL4-095	LL4so-095-0760-SO	No		Refusal at 1.0 ft
	3 to 5	LL4-095	LL4so-095-0761-SO	No		Refusal at 1.0 ft
	0 to 1	LL4-096	LL4ss-096-0762-SO	Yes	8/22/01	Prop. sample collected 8/24/01 at 1650; refusal at 0.5 ft; TNT = 9.5 mg/kg
	1 to 3	LL4-096	LL4so-096-0763-SO	No		Refusal at 0.5 ft
	3 to 5	LL4-096	LL4so-096-0764-SO	No		Refusal at 0.5 ft
	0 to 1	LL4-097	LL4ss-097-0765-SO	Yes	8/22/01	Refusal at 1.1 ft; TNT = 1.02 mg/kg
	1 to 3	LL4-097	LL4so-097-0766-SO	No		Refusal at 1.1 ft
	3 to 5	LL4-097	LL4so-097-0767-SO	No		Refusal at 1.1. ft
	0 to 1	LL4-098	LL4ss-098-0768-SO	Yes	8/22/01	TNT = 7.81 mg/kg
	1 to 3	LL4-098	LL4so-098-0769-SO	Yes	8/23/01	Refusal at 2 ft; TNT/RDX < 1 mg/kg
	3 to 5	LL4-098	LL4so-098-0770-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-099	LL4fs-099d-0771-FS	Yes	8/20/01	Floor sweep, TCLP, As^{+3}
G-19A Packing and Shipping	0 to 1	LL4-100	LL4ss-100-0772-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-100	LL4so-100-0773-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-100	LL4so-100-0774-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-101	LL4ss-101-0775-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-101	LL4so-101-0776-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-101	LL4so-101-0777-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-102	LL4ss-102-0778-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-102	LL4so-102-0779-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-102	LL4so-102-0780-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-103	LL4ss-103-0781-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-103	LL4so-103-0782-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-103	LL4so-103-0783-SO	No		Field explosives <1 mg/kg in surface sample
G-15 Explosive Preparation Building	0 to 1	LL4-104	LL4ss-104-0784-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-104	LL4so-104-0785-SO	No		Field explosives <1 mg/kg in surface sample

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	3 to 5	LL4-104	LL4so-104-0786-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-105	LL4ss-105-0787-SO	Yes	8/13/01	MC, pH; TNT = 1.5 mg/kg
	1 to 3	LL4-105	LL4so-105-0788-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-105	LL4so-105-1144-SO	Yes	8/23/01	Duplicate
	1 to 3	LL4-105	LL4so-105-1162-SO	Yes	8/23/01	Split
	3 to 5	LL4-105	LL4so-105-0789-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
	0 to 1	LL4-106	LL4ss-106-0790-SO	Yes	8/14/01	MC, pH; TNT/RDX < 1 mg/kg
	0 to 1	LL4-106	LL4ss-106-1147-SO	Yes	8/14/01	Duplicate
	0 to 1	LL4-106	LL4ss-106-1165-SO	Yes	8/14/01	Split
	1 to 3	LL4-106	LL4so-106-0791-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-106	LL4so-106-0792-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-107	LL4ss-107-0793-SO	Yes	8/12/01	MC, pH; TNT/RDX < 1 mg/kg
	1 to 3	LL4-107	LL4so-107-0794-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-107	LL4so-107-0795-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-108	LL4ss-108-0796-SO	Yes	8/13/01	Subfloor; TNT/RDX < 1 mg/kg
	0 to 1	LL4-109	LL4ss-109-0797-SO	Yes	8/13/01	Subfloor; TNT/RDX < 1 mg/kg
G-13 Funnel Removal and Face Off	0 to 1	LL4-110	LL4ss-110-0798-SO	Yes	8/12/01	MC, GS, pH, AL, SG, USCS; TNT/RDX < 1 mg/kg
	1 to 3	LL4-110	LL4so-110-0799-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-110	LL4so-110-0800-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-111	LL4ss-111-0801-SO	Yes	8/12/01	MC, pH; TNT/RDX < 1 mg/kg
	1 to 3	LL4-111	LL4so-111-0802-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-111	LL4so-111-0803-SO	No		Field explosives <1 mg/kg in surface sample
G-12A Explosives Cooling Building	0 to 1	LL4-112	LL4ss-112-0804-SO	Yes	8/21/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-112	LL4so-112-0805-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-112	LL4so-112-0806-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-113	LL4ss-113-0807-SO	Yes	8/21/01	TNT = 8.9 mg/kg
	1 to 3	LL4-113	LL4so-113-0808-SO	Yes	8/23/01	Refusal at 2.0 ft; TNT = 1.8 mg/kg
	3 to 5	LL4-113	LL4so-113-0809-SO	No		Refusal at 2.0 ft
	0 to 1	LL4-114	LL4ss-114-0810-SO	Yes	8/21/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-114	LL4so-114-0811-SO	No		Field explosives <1 mg/kg in surface sample

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	3 to 5	LL4-114	LL4so-114-0812-SO	No		Field explosives <1 mg/kg in surface sample
Settling Tank	0 to 1	LL4-115	LL4ss-115-0813-SO	Yes	8/14/01	Refusal at 0.8 ft; TNT/RDX < 1 mg/kg
	1 to 3	LL4-115	LL4so-115-0814-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-115	LL4so-115-0815-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-116	LL4ss-116-0816-SO	Yes	8/14/01	Refusal at 0.6 ft; TNT/RDX < 1 mg/kg
	0 to 1	LL4-116	LL4ss-116-1141-SO	Yes	8/14/01	Duplicate
	0 to 1	LL4-116	LL4ss-116-1159-SO	Yes	8/14/01	Split
	1 to 3	LL4-116	LL4so-116-0817-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-116	LL4so-116-0818-SO	No		Field explosives <1 mg/kg in surface sample
G-10 Explosive Preparation Building	0 to 1	LL4-117	LL4ss-117-0819-SO	Yes	8/21/01	MC, pH; TNT/RDX < 1 mg/kg
	1 to 3	LL4-117	LL4so-117-0820-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-117	LL4so-117-0821-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-118	LL4ss-118-0822-SO	Yes	8/21/01	MC, GS, pH, AL, SG, USCS; TNT/RDX < 1 mg/kg
	1 to 3	LL4-118	LL4so-118-0823-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-118	LL4so-118-0824-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-119	LL4ss-119-0825-SO	Yes	8/21/01	Subfloor; TNT/RDX < 1 mg/kg
	0 to 1	LL4-120	LL4ss-120-0826-SO	Yes	8/21/01	Subfloor; TNT/RDX < 1 mg/kg
G-8 Melt-pour Building	0 to 1	LL4-121	LL4ss-121-0827-SO	Yes	8/21/01	MC, pH; TNT/RDX < 1 mg/kg
	1 to 3	LL4-121	LL4so-121-0828-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-121	LL4so-121-0829-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-122	LL4ss-122-0830-SO	Yes	8/21/01	MC, pH; refusal at 0.7 ft; TNT/RDX < 1 mg/kg
	1 to 3	LL4-122	LL4so-122-0831-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-122	LL4so-122-0832-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-123	LL4ss-123-0833-SO	Yes	8/14/01	Subfloor; TNT/RDX < 1 mg/kg
	0 to 1	LL4-124	LL4ss-124-0834-SO	Yes	8/14/01	Subfloor; TNT/RDX < 1 mg/kg
	0 to 1	LL4-125	LL4fs-125d-0835-FS	Yes	8/20/01	Floor sweep, As^{+3}, TCLP
G-3 Inert Storage	0 to 1	LL4-126	LL4ss-126-0836-SO	Yes	8/22/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-126	LL4so-126-0837-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-126	LL4so-126-0838-SO	No		Field explosives <1 mg/kg in surface sample

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	0 to 1	LL4-127	LL4ss-127-0839-SO	Yes	8/20/01	Refusal at 1.0 ft; TNT = 1.4 mg/kg
	1 to 3	LL4-127	LL4so-127-0840-SO	No		Refusal at 1.0 ft
	3 to 5	LL4-127	LL4so-127-0841-SO	No		Refusalt at 1.0 ft
	0 to 1	LL4-128	LL4ss-128-0842-SO	Yes	8/20/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-128	LL4so-128-0843-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-128	LL4so-128-0844-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-129	LL4fs-129d-0845-FS	Yes	8/20/01	Floor sweep, As^{+3}, TCLP
G-4 Boiler House	0 to 1	LL4-130	LL4ss-130-0846-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-130	LL4so-130-0847-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-130	LL4so-130-0848-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-131	LL4ss-131-0849-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-131	LL4ss-131-1143-SO	Yes	8/14/01	Duplicate
	0 to 1	LL4-131	LL4ss-131-1161-SO	Yes	8/14/01	Split
	1 to 3	LL4-131	LL4so-131-0850-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-131	LL4so-131-0851-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-132	LL4ss-132-0852-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-132	LL4so-132-0853-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-132	LL4so-132-0854-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-133	LL4ss-133-0855-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-133	LL4so-133-0856-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-133	LL4so-133-0857-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-134	LL4ss-134-0858-SO	Yes	8/14/01	Subfloor; TNT/RDX < 1 mg/kg
	0 to 1	LL4-135	LL4ss-135-0859-SO	Yes	8/14/01	Subfloor; TNT/RDX < 1 mg/kg
G-6 Change House	0 to 1	LL4-136	LL4ss-136-0860-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-136	LL4so-136-0861-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-136	LL4so-136-0862-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-137	LL4ss-137-0863-SO	Yes	8/14/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-137	LL4so-137-0864-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-137	LL4so-137-0865-SO	No		Field explosives <1 mg/kg in surface sample
G-6A Change House	0 to 1	LL4-138	LL4ss-138-0866-SO	Yes	8/21/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-138	LL4so-138-0867-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-138	LL4so-138-0868-SO	No		Field explosives <1 mg/kg in surface sample

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
	0 to 1	LL4-139	LL4ss-139-0869-SO	Yes	8/21/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-139	LL4so-139-0870-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-139	LL4so-139-0871-SO	No		Field explosives <1 mg/kg in surface sample
Contingency Samples						
Building G-11 at North LL4 Fence Boundary	0 to 1	LL4-140	LL4ss-140-0872-SO	Yes	8/26/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-140	LL4so-140-0873-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-140	LL4so-140-0874-SO	No		Field explosives <1 mg/kg in surface sample
Building G-6	0 to 1	LL4-141	LL4ss-141-0875-SO	Yes	8/14/01	Cr^{+6}; TNT/RDX < 1 mg/kg
	1 to 3	LL4-141	LL4so-141-0876-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-141	LL4so-141-0877-SO	No		Field explosives <1 mg/kg in surface sample
Building G-8	0 to 1	LL4-142	LL4ss-142-0878-SO	Yes	8/24/01	Steam line north side of building; Cr^{+6} analysis. MC, pH; TNT < 1 mg/kg, RDX = 11.46 mg/kg
	0 to 1	LL4-142	LL4ss-142-1142-SO	Yes	8/24/01	Duplicate
	0 to 1	LL4-142	LL4ss-142-1160-SO	Yes	8/24/01	Split sample: not sent for Cr^{+6} analysis.
	1 to 3	LL4-142	LL4so-142-0879-SO	Yes	8/25/01	TNT/RDX < 1 mg/kg
	3 to 5	LL4-142	LL4so-142-0880-SO	No		Field explosives < 1 mg/kg in 1-3 ft sample
Building G-16 Sediment Basin	0 to 1	LL4-143	LL4ss-143-0881-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	1 to 3	LL4-143	LL4so-143-0882-SO	No		Field explosives <1 mg/kg in surface sample
	3 to 5	LL4-143	LL4so-143-0883-SO	No		Field explosives <1 mg/kg in surface sample
	0 to 1	LL4-144	LL4so-144-0884-SO	No		Reallocated to LL4sd-144-0884SD; TNT/RDX < 1 mg/kg
	1 to 3	LL4-144	LL4so-144-0885-SO	No		No subsurface sediment
	3 to 5	LL4-144	LL4so-144-0886-SO	No		No subsurface sediment
	0 to 1	LL4-145	LL4so-145-0887-SO	No		Reallocated to LL4sd-145-0887SD; TNT/RDX < 1 mg/kg
	1 to 3	LL4-145	LL4so-145-0888-SO	No		No subsurface sediment
	3 to 5	LL4-145	LL4so-145-0889-SO	No		No subsurface sediment
	0 to 1	LL4-146	LL4ss-146-0890-SO	No		No explanation given
	1 to 3	LL4-146	LL4so-146-0891-SO	No		No explanation given
	3 to 5	LL4-146	LL4so-146-0892-SO	No		No explanation given

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
Random Grid in Non-Production Areas						
	0 to 1	LL4-150	LL4ss-150-0902-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-150	LL4ss-150-1149-SO	Yes	8/23/01	Duplicate
	0 to 1	LL4-150	LL4ss-150-1167-SO	Yes	8/23/01	Split
	0 to 1	LL4-151	LL4ss-151-0903-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-152	LL4ss-152-0904-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-153	LL4ss-153-0905-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-154	LL4ss-154-0906-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-155	LL4ss-155-0907-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-156	LL4ss-156-0908-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-157	LL4ss-157-0909-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-158	LL4ss-158-0910-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-159	LL4ss-159-0911-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-160	LL4ss-160-0912-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-161	LL4ss-161-0913-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-161	LL4ss-161-1150-SO	Yes	8/24/01	Duplicate
	0 to 1	LL4-161	LL4ss-161-1168-SO	Yes	8/24/01	Split
	0 to 1	LL4-162	LL4ss-162-0914-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-163	LL4ss-163-0915-SO	Yes	8/24/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-164	LL4ss-164-0916-SO	Yes	8/23/01	Refusal at 0.75 ft; TNT/RDX < 1 mg/kg
	0 to 1	LL4-165	LL4ss-165-0917-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
	0 to 1	LL4-166	LL4ss-166-0918-SO	Yes	8/23/01	TNT/RDX < 1 mg/kg
Perimeter Trenches						
		LL4-167	LL4tr-167-0919-SO	No		Not selected for analysis
			LL4tr-167-0920-SO	No		Not selected for analysis
			LL4 tr-167-0921-SO	No		Not selected for analysis
			LL4 tr-167-0922-SO	No		Not selected for analysis
	2.0 to 2.5	LL4-168	LL4 tr-168-0923-SO	Yes	8/22/01	MC, GS, pH, AL, SG, USCS
	7.0		LL4 tr-168-0924-SO	Yes	8/22/01	MC, GS, pH, AL, SG, USCS
	8.5 to 9.0		LL4 tr-168-0925-SO	Yes	8/22/01	MC, GS, pH, AL, SG, USCS
	11.0		LL4 tr-168-0926-SO	Yes	8/22/01	MC, GS, pH, AL, SG, USCS
		LL4-169	LL4 tr-169-0927-SO	No		Not selected for analysis

Table 3-2. Soil Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
			LL4 tr-169-0928-SO	No		Not selected for analysis
			LL4 tr-169-0929-SO	No		Not selected for analysis
			LL4 tr-169-0930-SO	No		Not selected for analysis
		LL4-170	LL4tr--170-0931-SO	No		Not selected for analysis
			LL4tr-170-0932-SO	No		Not selected for analysis
			LL4tr-170-0933-SO	No		Not selected for analysis
			LL4tr-170-0934-SO	No		Not selected for analysis
	3.0 to 3.5	LL4-171	LL4tr-171-0935-SO	Yes	8/21/01	MC, GS, pH, AL, SG, USCS
	10.0		LL4tr-171-0936-SO	Yes	8/21/01	MC, GS, pH, AL, SG, USCS
			LL4tr-171-0937-SO	No		Not selected for analysis
			LL4tr-171-0938-SO	No		Not selected for analysis
		LL4-172	LL4tr-172-0939-SO	No		Not selected for analysis
			LL4tr-172-0940-SO	No		Not selected for analysis
			LL4tr-172-0941-SO	No		Not selected for analysis
			LL4tr-172-0942-SO	No		Not selected for analysis

AL = Atterberg limits.
As^{+3} = Trivalent arsenic.
CN = Cyanide.
Cr^{+6} = Hexavalent chromium.
Exp = Explosives.
GS = Grain size.
HC = Hydraulic conductivity.
ID = Identification.
MC = Moisture content.
PCB = Polychlorinated biphenyl.
Prop = Propellants (nitrocellulose, nitroglycerine, nitroguanidine).
RI = Remedial Investigation.
SG = Specific gravity.
SVOC = Semivolatile organic compound.
TCLP = Toxicity Characteristic Leaching Procedure.
USCS = Unified Soil Classification System.
VOC = Volatile organic compound.

results of the soil sample analyses were also used to quantify risks to human and ecological receptors that may be exposed to soil (see Chapters 6.0 and 7.0).

3.1.1.1 Surface and subsurface soil

As presented in Table 3-2, soil sampling locations were categorized by geographic location and sample type. The categories include (1) source area characterization, including buildings and structures; (2) contingency samples; and (3) random grid samples in non-production areas. The rationales for collection of these categories of samples were based on the CSM as presented in Chapter 2.0 and are summarized below. When developing EUs for evaluation of contaminant nature and extent and risks to human and ecological receptors (Section 4.1), these samples were assigned to specific EUs based on geographic location and rationale for collection.

Source Area Characterization

Soil samples were collected primarily at former operations and support areas that were thought to represent potential source areas for contamination (functional areas 1 through 20). Sampling locations were selected on the basis of operational records, the project DQOs, and the analytical results from previous sampling events (Phase I RI) to characterize contaminant nature and extent. Soil sampling around potential sources was biased to locations most likely to exhibit contamination (e.g. collected from the soil interval immediately beneath the ballast layer; they are addressed as surface soil samples in the nature and extent and risk evaluations although the overlying ballast layer was up to 0.6 m (2 ft) thick in areas.

In addition to planned biased samples activities, source area characterization incorporated the use of color spectrophotometry, or colorimetry, to analyze for TNT and RDX in a field laboratory (see Section 3.7.1). The rationale for employing the field analytical methods was to identify the presence of explosive compounds at a specific sample location on a "real-time" basis to help determine lateral and vertical characterization of explosives compounds. Figure 3-4 illustrates the application of explosives field analysis in guiding sampling Phase II RI sampling efforts. At stations where these compounds were identified at concentrations greater than 1 mg/kg in the surface soil interval, data were evaluated to determine if additional samples were required at a location to determine horizontal extent of contamination. All samples that had field TNT or RDX concentrations greater than 1 mg/kg were submitted to a fixed-based off-site laboratory for confirmatory analyses. In addition, 15% of the samples having no detected TNT or RDX using the field methods were submitted to an off-site laboratory for analyses for QA purposes.

A total of 93 surface soil samples were collected around potential source areas. Additionally, samples were collected from beneath building floors to evaluate any contaminant releases through cracks in floor slabs or leaking drains. A total of nine soil samples was collected from beneath building floor slabs.

Contingency Samples

Five contingency sample locations were identified during the Phase II sampling activities. Contingency samples were collected based on specific field conditions and observations made during the field effort. Such field observations included potential evidence of contamination (e.g., stained soil) or specific data needs (e.g., Cr^{+6} characterization near former steam lines). Contingency samples were assigned to their appropriate data aggregates during development of EUs in Chapter 4.0.

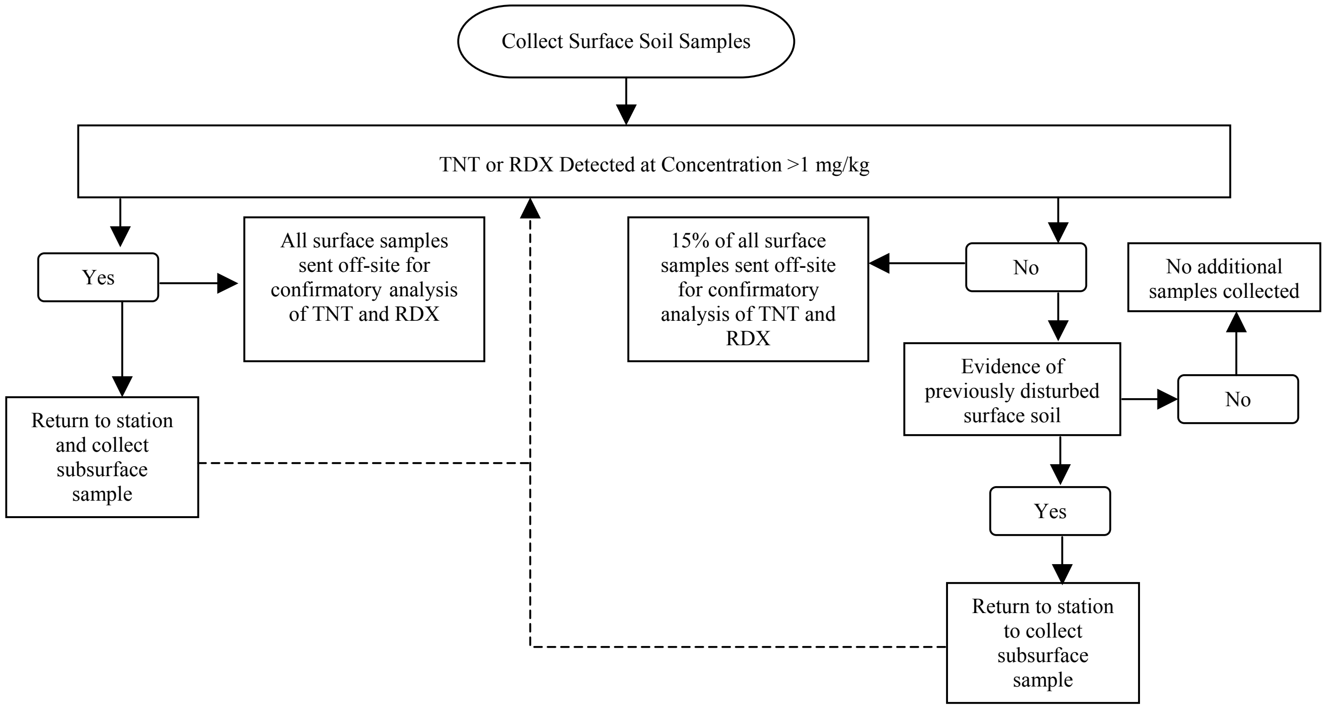

Figure 3-4. Field Explosives Analysis Screening Rationale

Random Grid Samples in Non-Production Areas

To effectively characterize large areas outside of the immediate production complex of the AOC with a high degree of confidence [e.g., non-production areas (functional area 27)], a statistically based random sampling method was employed (Gilbert 1987). Non-production areas were divided into 17 EUs, each encompassing of a few acres (Figure 3-3). EUs were employed to account for potential future residential land use in that a typical residential property owner would not be expected to purchase and use land tracts of more than a few acres. One surface soil sample was collected within each EU. For each EU, a triangular sampling grid having a grid spacing of 18.3 m (60 ft) was superimposed. The grid spacing selected was sufficient to locate a hypothetical elliptical contamination “hotspot” having dimensions of 30.5 m (100 ft) by 15.2 m (50 ft), with a confidence factor of 95%. Each node (or line intersection) on the grid was assigned a numerical value. A random number generator was employed to identify a specific node within each EU at which a sample would be collected.

Subsurface Soil

Subsurface soil sampling strategy was based on the use of field analyses for TNT and RDX discussed previously. At stations where TNT and RDX were identified in the surface soil interval 0 to 0.3 m (0 to 1 ft) at concentrations greater than 1 mg/kg, field teams would return to the station to collect a sample from the 0.3- to 0.9-m (1- to 3-ft) subsurface interval. This process was repeated for subsequent subsurface intervals based on results of the field explosives analyses. Due to the high adsorption factors for explosive compounds and given that most releases at RVAAP were to the ground surface, the absence of TNT or RDX above 1 mg/kg in the surface interval was presumed to indicate that explosives were not present in the subsurface (unless evidence existed that soil had been disturbed). Thus, if field analyses indicated a lack of detectable explosives in the surface soil interval, subsurface samples were not collected.

Following the decision process above, the option to collect subsurface soil samples at any designated surface soil location was incorporated into the sampling planning process. During scoping of the Phase II RI, provisions were made for approximately 13 subsurface soil samples. A total of 13 subsurface soil samples (including contingencies) were ultimately collected from the 0.3- to 0.9-m (1- to 3-ft) bgs interval based on field TNT or RDX above 1 mg/kg; no samples were collected from the 0.9- to 1.6-m (3- to 5-ft) bgs interval due to the absence of detectable TNT or RDX in the field laboratory.

3.1.1.2 Test pits

To provide a better understanding of subsurface stratigraphy and factors affecting shallow groundwater flow, test pits were excavated at six locations around the outer perimeter of the AOC where the vadose zone was presumed to be uncontaminated (Figure 3-5). Stratigraphic and geotechnical data were collected from the test pits that would not ordinarily be obtained through conventional soil borings or direct-push sampling techniques. Characterization of the unconsolidated zone was accomplished through visual examination of subsurface materials and collection of geotechnical samples representing different depth intervals. Disturbed samples for geotechnical analyses were collected at Test Pit 2 (LL4-168) and Test Pit 5 (LL4-171). A sequence of four samples at various depths was collected from Test Pit 2 and a sequence of two samples from Test Pit 5 to provide a vertical profile of geotechnical characteristics and to characterize different soil types encountered in the pits. Samples for chemical analyses were not planned or collected (Table 3-2). The total depth of each of the test pits is listed below.

Test Pit 1 (LL4-167) = 12.5 ft,
Test Pit 2 (LL4-168) = 12.9 ft,
Test Pit 3 (LL4-169) = 12.6 ft,
Test Pit 4 (LL4-170) = 13.2 ft,
Test Pit 5 (LL4-171) = 12.0 ft, and
Test Pit 6 (LL4-172) = 14.1 ft.

3.1.1.3 Floor sweep samples

To provide data for future building demolition activities, floor sweep samples were collected from two buildings (G-3 and G-8). The samples were collected from random areas within the buildings and analyzed for chemical constituents, including As^{+3}, in order to determine if residual explosives dust, lead or PCB-based paint chips, or other contaminants were present that could affect demolition activities or waste management planning. In addition to chemical analyses, these samples were submitted for Toxicity Characteristic Leaching Procedure (TCLP) analyses to determine if any of the materials might exhibit hazardous characteristics.

3.1.1.4 Geotechnical samples

Disturbed soil samples for geotechnical analyses were collected from a total of 27 stations (Table 3-2). Twenty-one disturbed surface soil geotechnical samples were collected from hand auger borings. Six representative samples were collected from test pits (see Section 3.1.1.2). Analysis of these samples was performed to determine specific geotechnical properties necessary to evaluate media-specific fate and transport mechanisms and potential remedial alternatives.

Thirteen undisturbed Shelby tube samples, a minimum of one per boring, were collected from the eight monitoring well borings drilled during the Phase II RI (Figure 3-5). An undisturbed sample was collected from within the monitoring interval of each well. In addition, a near surface sample was collected from most borings for further characterization purposes.

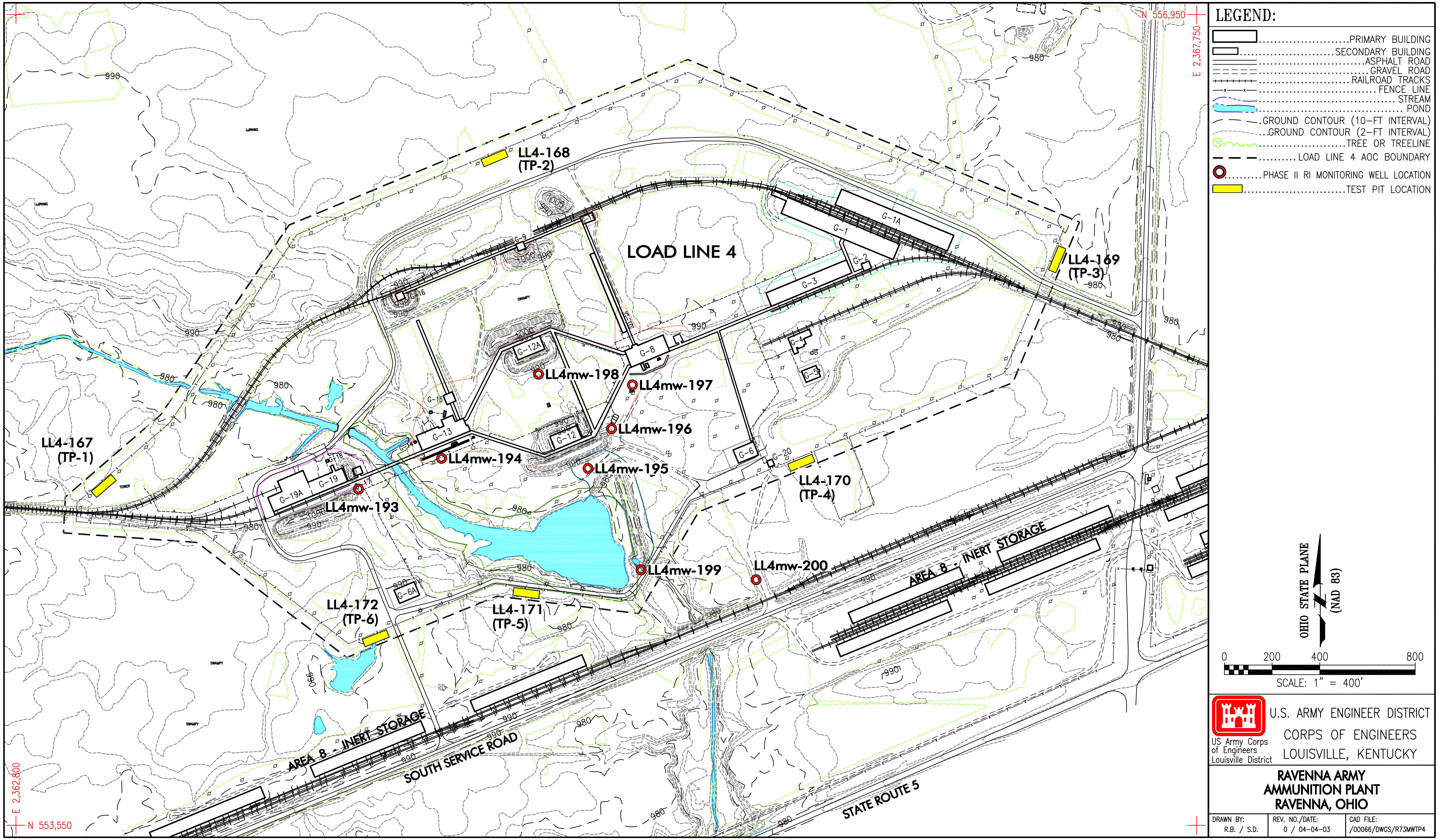

Figure 3-5. Phase II RI Monitoring Well and Test Pit Locations for Load Line 4

3.1.2 Surface and Subsurface Soil Field Sampling Methods

3.1.2.1 Surface soil and dry sediment

A decontaminated stainless steel bucket hand auger was used to collect surface soil samples at each station. The target depth interval for surface soil samples was 0 to 0.3 m (0 to 1 ft). Where explosives and propellant analyses were not specified, a single boring was hand augered at the approved locations. Soil for VOC analyses was placed directly into sample jars from the auger bucket. The remaining soil was placed into a stainless steel bowl and homogenized. Samples for inorganic constituents (metals and cyanide), SVOCs, and other non-volatile constituents were collected from the homogenized soil mixture.

Where analyses for explosives and propellant compounds were specified, composite samples were collected. Because of the physical characteristics of these explosives and propellant compounds (e.g., flakes, particles, and pellets) and the nature of process operations, the distribution of these types of compounds can be erratic and highly variable. Composite sampling has been shown to reduce statistical sampling error in surface soil at sites with a history of explosives contamination in surface soil (Jenkins et al. 1996) and to increase the likelihood of capturing detectable levels of explosive compounds over a given area. Composite sampling data are considered acceptable to EPA for use in risk assessment where concentrations are expected to vary spatially (EPA 1989a). To collect composite samples for surface soil and dry sediment, three borings were hand augered in an equilateral triangle pattern measuring about 0.9 m (3 ft) on a side. Equal portions of soil from the three sub-samples were placed into a large, decontaminated stainless steel bowl, homogenized, and the samples for explosive and propellant compounds analyses placed into sample containers. A portion of the sample was extracted from the sample container for field colorimetric analysis of TNT and RDX. Samples for analyses of other contaminants (e.g., inorganics, SVOCs, VOCs, etc.) were collected from a boring placed in the approximate center of the triangle formed by the three sub-samples.

For samples collected beneath building floor slabs, coring of the concrete floor slabs was required. Locations selected for coring targeted observed cracks in the floor slab or adjacent to drains through which contaminants could potentially migrate. Discrete samples were collected from the first 0.3-m (1-ft) interval beneath the floor slab using a bucket auger as described above.

Field descriptions and classifications for the soil samples were performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility-wide SAP as specified in the Phase II RI SAP Addendum, with the following exception. Headspace gases were not screened in the field for organic vapors. Organic vapor measurements were made in the breathing zone during sampling and the results recorded in the field logbooks.

Following collections of the sample, excess soil was designated as IDW and placed in lined, labeled 55-gal drums that were sealed after use and staged at the designated field staging area within the load line. IDW practices for all media are discussed in Appendix P**.** Hand auger borings were backfilled to the ground surface with dry bentonite chips following collection of all necessary surface and subsurface soil samples.

3.1.2.2 Subsurface soil sampling methods

To collect subsurface samples for chemical analyses, a decontaminated auger bucket was used to deepen the surface soil boring over the required depth interval. At locations where composite sampling was performed for explosive and propellant compound analysis, the subsurface sample was obtained by deepening the surface soil boring located in the center of the equilateral triangle. For composite sampling stations where refusal occurred in the center boring, the subsurface samples were collected by deepening one of three equilateral sub-sampling points.

Soil from the subsurface interval was placed into a stainless steel bowl, homogenized, and representative aliquots were placed into the appropriate sample containers. All VOC samples were collected as discrete aliquots from the middle of the interval without homogenization. As with surface soil samples, a portion of the sample designated for explosives and propellant compound analyses was extracted from the sample container for field colorimetric analysis of TNT and RDX. As required by field method results or for confirmation purposes, the remaining portion was submitted to the fixed-base laboratory for additional analysis.

Field descriptions and classification of the soils were performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility-wide SAP as specified in the Phase II RI SAP Addendum, with the following exception. Headspace gases were not screened in the field for organic vapors. Organic vapor measurements were made in the breathing zone during sampling and at the top of the boring and recorded in the field logbooks.

Following collections of the sample, excess soil was designated as IDW and placed in lined, labeled 55-gal drums that were sealed after use and staged at the designated field staging area within the load line. IDW practices for all media are discussed in Appendix P. Hand auger borings were backfilled to the ground surface with dry bentonite chips.

3.1.2.3 Test pits

Test pits were excavated using a backhoe excavator with a 61-cm (24-in.) bucket to depths ranging from 3.9 m (12 ft) to 4.6 m (14.1 ft). Excavation was terminated at either the maximum depth capability of the excavator or if bedrock was encountered in any test pit. Wet substrates and seepage points were encountered at depths ranging from 3.3 m (10 ft) to 3.9 m (12 ft) bgs in test pits 4, 5, and 6. Groundwater seepage was not observed in test pits 1, 2, or 3. Test pit logs are contained in Appendix E.

Soil extracted from the test pits was logged using conventional geologic and geotechnical methods, including visual Unified Soil Classification System (USCS) classification and standard Munsell® Soil Color Charts (Munsell 1988). Sample sequences were collected as described in Section 3.1.1.2. Headspace gases were not screened in the field for organic vapors. Organic vapor measurements were made in the breathing zone during sampling and at the top of the boring and recorded in the field logbooks.

3.2 SEDIMENT CHARACTERIZATION

3.2.1 Rationale

Sediment samples were collected from a total of 16 stations located within drainage conveyances, stream channels, and ponds (Table 3-3; Figure 3-6). Fourteen of these stations were repeat sampling of Phase I RI stations; 2 stations were added under the Phase II RI scope. These samples were collected to evaluate contaminant migration from surface soil sources via erosional processes and accumulation within these features. The analytical results for sediment samples collected from surface drainage features were used to quantify risks to human and ecological receptors that may be exposed to sediment (see Chapters 6.0 and 7.0). Sediment samples from drainage conveyances that are predominantly dry, except during storm events, were addressed as soil in the development of EUs and the risk evaluations. Samples collected from perennial streams and ponds were addressed as true sub-aqueous sediment in the nature and extent and risk evaluations.

Two samples of accumulated sediments and sludges were also collected from the Building G-8 washout basin (station LL4-175) and the sediment basin north of Building G-16 (station LL4-144). These samples were collected to help characterize residual contaminants in buildings and structures for the purposes of

Table 3-3. Sediment Sample List and Rationales, Load Line 4 Phase II RI

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
Associated with Buildings						
G-8 Melt-pour Building at Washout Basin	0 to 0.5	LL4-175	LL4sd-175-0951-SD	Yes	8/14/01	TNT = 24.6 mg/kg
	0 to 0.5	LL4-175	LL4sd-175-1145-SD	Yes	8/14/01	Duplicate
	0 to 0.5	LL4-175	LL4sd-175-1163-SD	Yes	8/14/01	Split
Storm Water Ditches/Sewer						
Re-sample Phase I LL4-013	0 to 0.5	LL4-013	LL4sd-013-0953-SD	Yes	8/11/01	GS, TOC
Re-sample Phase I LL4-021	0 to 0.5	LL4-021	LL4sd-021-0954-SD	Yes	8/11/01	
Re-sample Phase I LL4-044	0 to 0.5	LL4-044	LL4sd-044-0955-SD	Yes	8/13/01	
Re-sample Phase I LL4-048	0 to 0.5	LL4-048	LL4sd-048-0957-SD	Yes	8/20/01	GS, TOC
Re-sample Phase I LL4-049	0 to 0.5	LL4-049	LL4sd-049-0959-SD	Yes	8/20/01	
Re-sample Phase I LL4-050	0 to 0.5	LL4-050	LL4sd-050-0961-SD	Yes	8/12/01	
Re-sample Phase I LL4-051	0 to 0.5	LL4-051	LL4sd-051-0962-SD	Yes	8/13/01	
Re-sample Phase I LL4-052 (Pond)	0 to 0.5	LL4-052	LL4sd-052-0963-SD	Yes	8/14/01	
Re-sample Phase I LL4-053 (Pond)	0 to 0.5	LL4-053	LL4sd-053-0965-SD	Yes	8/14/01	
Re-sample Phase I LL4-054 (Pond)	0 to 0.5	LL4-054	LL4sd-054-0967-SD	Yes	8/14/01	GS, TOC
Re-sample Phase I LL4-055 (Pond)	0 to 0.5	LL4-055	LL4sd-055-0969-SD	Yes	8/14/01	
Re-sample Phase I LL4-056	0 to 0.5	LL4-056	LL4sd-056-0971-SD	Yes	8/13/01	GS, TOC
R-esample Phase I LL4-057	0 to 0.5	LL4-057	LL4sd-057-0973-SD	Yes	8/13/01	GS, TOC
Re-sample Phase I LL4-058	0 to 0.5	LL4-058	LL4sd-058-0975-SD	Yes	8/20/01	GS, TOC
MH 2	0 to 0.5	LL4-176	LL4sd-176-0977-SD	Yes	8/12/01	TNT/RDX < 1 mg/kg
IN F3	0 to 0.5	LL4-177	LL4sd-177-0979-SD	Yes	8/12/01	TNT/RDX < 1 mg/kg
	0 to 0.5	LL4-177	LL4sd-177-1140-SD	Yes	8/12/01	Duplicate
	0 to 0.5	LL4-177	LL4sd-177-1158-SD	Yes	8/12/01	Split
MH 7	0 to 0.5	LL4-178	LL4sd-178-0980-SD	Yes	8/12/01	TNT/RDX < 1 mg/kg
MH 9	0 to 0.5	LL4-179	LL4sd-179-0981-SD	No		No sediment. Sample reallocated to IDW characterization
MH 3	0 to 0.5	LL4-180	LL4sd-180-0982-SD	No		No sediment
MH 5	0 to 0.5	LL4-181	LL4sd-181-0984-SD	No		No sediment
MH 11	0 to 0.5	LL4-182	LL4sd-182-0986-SD	No		No sediment
MH 13	0 to 0.5	LL4-183	LL4sd-183-0988-SD	No		No sediment
MH 15	0 to 0.5	LL4-184	LL4sd-184-0989-SD	No		No sediment

Table 3-3. Sediment Sample List and Rationales, Load Line 4 Phase II RI (continued)

Facility/Building No.	Depth (ft)	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/Rationales
OF of IN GA 7	0 to 0.5	LL4-185	LL4sd-185-0990-SD	Yes	8/11/01	GS, TOC; TNT/RDX , 1 mg/kg
Sanitary Sewer						
MH W4-3	0 to 0.5	LL4-186	LL4sd-186-0991-SD	Yes	8/20/01	TNT/RDX < 1 mg/kg
MH W4	0 to 0.5	LL4-187	LL4sd-187-0993-SD	Yes	8/20/01	TNT/RDX < 1 mg/kg
MH W3	0 to 0.5	LL4-188	LL4sd-188-0995-SD	Yes	8/20/01	TNT/RDX < 1 mg/kg
MH W1	0 to 0.5	LL4-189	LL4sd-189-0997-SD	Yes	8/13/01	TNT/RDX < 1 mg/kg
MH 419	0 to 0.5	LL4-190	LL4sd-190-0999-SD	Yes	8/13/01	TNT/RDX < 1 mg/kg
Ejector Station	0 to 0.5	LL4-191	LL4sd-191-1001-SD	No		No sediment
MH E2	0 to 0.5	LL4-192	LL4sd-192-1003-SD	Yes	8/13/01	TNT/RDX < 1 mg/kg
MH E6	0 to 0.5	LL4-193	LL4sd-193-1005-SD	No		No sediment
Sediment Basin N of Building G-16	0 to 0.5	LL4-144	LL4sd-144-0884-SD	Yes	8/24/01	
Drainage Outlet from LL4 Pond	0 to 0.5	LL4-145	LL4sd-145-0887-SD	Yes	8/13/01	
	0 to 0.5	LL4-145	LL4sd-145-1137-SD	Yes	8/13/01	Duplicate
	0 to 0.5	LL4-145	LL4sd-145-1155-SD	Yes	8/13/01	Split

CN = Cyanide.
Cr^{+6} = Hexavalent chromium.
Exp = Explosives.
GS = Grain size.
MH = Manhole.
PCB = Polychlorinated biphenyl.
Prop = Propellants (nitrocellulose, nitroglycerine, nitroguanidine).
RI = Remedial Investigation.
SVOC = Semivolatile organic compound.
TOC = Total organic compound.
VOC = Volatile organic compound.

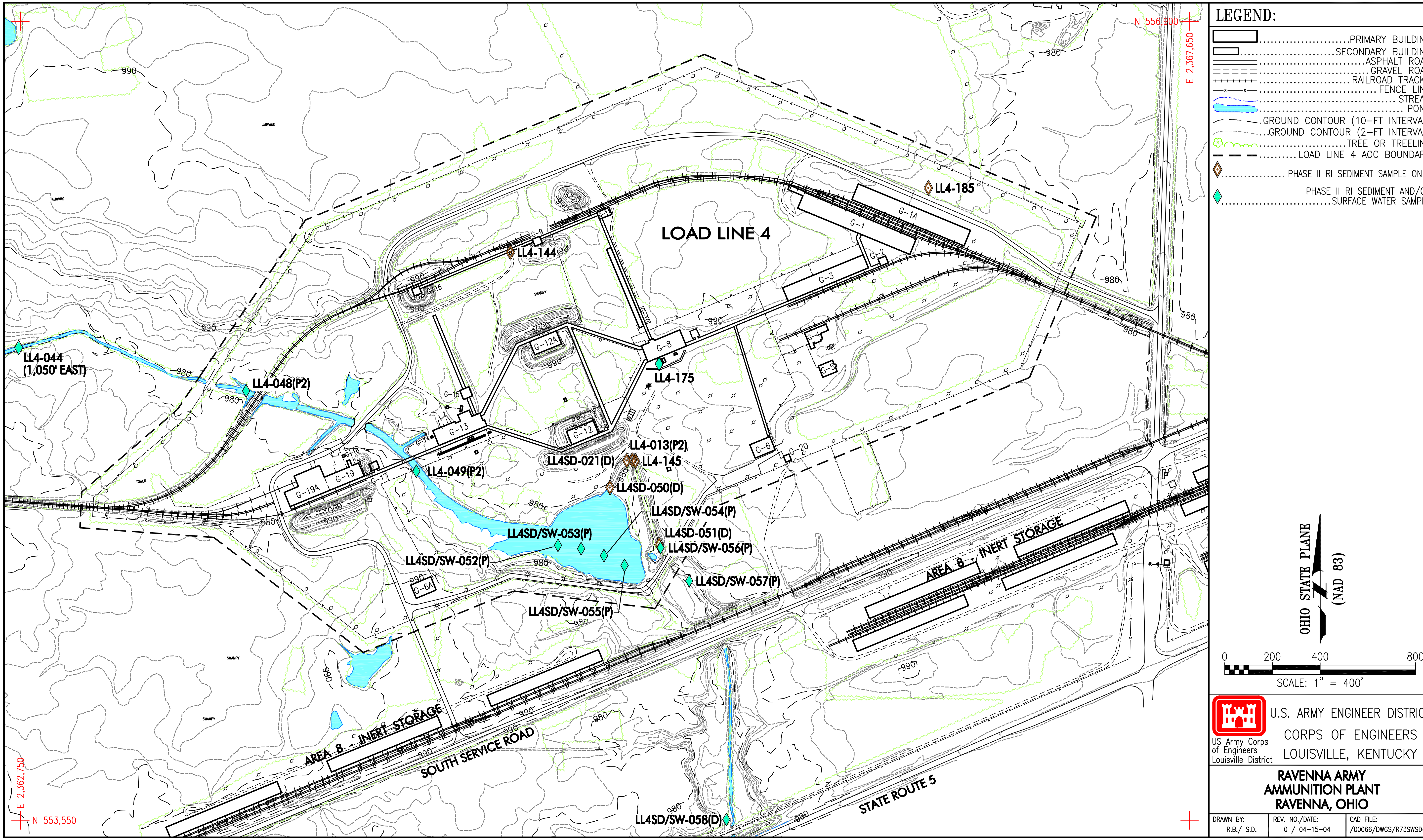

Figure 3-6. Phase II RI Sediment and Surface Water Sampling Locations at Load Line 4

demolition and waste management planning. These samples were considered separately in the evaluation of contaminant nature and extent and were not evaluated with respect to risk.

Accumulated sediments were also collected from nine points within the storm and sanitary sewer networks (inlets and manhole locations); these are discussed separately in Section 3.5.

Table 3-3 details the various types of sediment samples collected for the Phase II RI. Departures from the planned sampling efforts due to site conditions (i.e., lack of sufficient sample material) and the addition of contingency samples are specifically denoted. In addition to chemical analyses, seven sediment samples from various locations were submitted for geotechnical analyses [grain size and total organic carbon (TOC)] to help qualitatively evaluate contaminant sorption and natural attenuation characteristics.

3.2.2 Sediment Field Sampling Methods

Dry sediment samples from ditch lines and low-lying areas were collected using the hand bucket auger method as described for surface soil samples noted in Section 3.1.2.1. Sub-aqueous sediment was collected with a decontaminated stainless steel trowel or scoop using the methods described in Section 4.5.2.1.2 of the Facility-wide SAP (USACE 2001c), as referenced by the Phase II RI SAP Addendum, where the sampling stations had less than about 30 cm (1.0 ft) of water. For perennial streams and pond sampling locations where the depth of water exceeded about 30 cm (1.0 ft), a clamshell sampler was used to obtain sediment. For samples collected using both trowels and the clamshell sampler, extracted material was placed into a stainless steel bowl. At sample locations where VOC samples were to be collected, the VOC containers were immediately filled with the first materials obtained. Sample containers for the remaining nonvolatile analytes were then filled.

For sediment samples from within structures and building (e.g., settling basins and sumps), a trowel or clamshell sampler was employed depending on the presence and depth of accumulated water within the structures. As a safety precaution, samples from washout annexes inside the melt-pour buildings were collected by UXO avoidance personnel. UXO avoidance personnel were trained by SAIC field staff on proper collection techniques prior to sampling. Upon collection and visual examination of samples by UXO avoidance personnel, the samples were transferred to on-site SAIC field staff for sample packaging and shipping.

Field description of the sediment samples was performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility-wide SAP (USACE 2001c), as specified in the Phase II RI SAP Addendum. Headspace gases were not screened in the field for organic vapors. Organic vapor measurements made in the breathing zone during sampling were recorded in the field logbooks.

3.3 SURFACE WATER CHARACTERIZATION

3.3.1 Rationales

Surface water represents the primary contaminant transport pathway off of the AOC, either as dissolved phase or adsorbed to particulates/sediment that are mobilized by flow. Surface water data obtained were used to evaluate ambient water quality entering the AOC, as well as to assess potential impacts from other potential source areas. Load Line 4 drainage is overall toward the south. A tributary crosses the west-central portion of the AOC and terminates in a pond located in the southern portion of the AOC. Flow from the pond discharges to the south off of RVAAP.

Perennial streams and ponds were the focal areas of the surface water sampling during the Phase II RI; these samples are addressed as viable ecological habitat in the nature and extent and risk evaluations. Re-sampling of surface water at 10 Phase I RI stations was completed as planned (Table 3-4; Figure 3-6). These Phase I RI stations were chosen for sampling because they are located within water bodies that exit the load line.

Table 3-4. Surface Water Sample List and Rationales, Load Line 4 Phase II RI

Facility/Building No.	Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Comments/ Rationales
Associated with Buildings					
G-8 Melt-pour Building at Washout Basin	LL4-175	LL4sw-175-0952-SW	Yes	8/14/01	
Storm Water Ditches/Sewer					
Re-sample Phase I LL4-044	LL4-044	LL4sw-044-0956-SW	Yes	8/13/01	
Re-sample Phase I LL4-048	LL4-048	LL4sw-048-0958-SW	Yes	8/20/01	
Re-sample Phase I LL4-049	LL4-049	LL4sw-049-0960-SW	Yes	8/20/01	
Re-sample Phase I LL4-052 (Pond)	LL4-052	LL4sw-052-0964-SW	Yes	8/14/01	
Re-sample Phase I LL4-053 (Pond)	LL4-053	LL4sw-053-0966-SW	Yes	8/14/01	
Re-sample Phase I LL4-054 (Pond)	LL4-054	LL4sw-054-0968-SW	Yes	8/14/01	
Re-sample Phase I LL4-055 (Pond)	LL4-055	LL4sw-055-0970-SW	Yes	8/14/01	
Re-sample Phase I LL4-056	LL4-056	LL4sw-056-0972-SW	Yes	8/13/01	
Re-sample Phase I LL4-057	LL4-057	LL4sw-057-0974-SW	Yes	8/13/01	
Re-sample Phase I LL4-058	LL4-058	LL4sw-058-0976-SW	Yes	8/14/01	
MH 2	LL4-176	LL4sw-176-0978-SW	Yes	8/12/01	
MH 3	LL4-180	LL4sw-180-0983-SW	Yes	8/12/01	
MH 5	LL4-181	LL4sw-181-0985-SW	No		Location was dry
MH 11	LL4-182	LL4sw-182-0987-SW	Yes	8/12/01	
Sanitary Sewer					
MH W4-3	LL4-186	LL4sw-186-0992-SW	Yes	8/20/01	
MH W4	LL4-187	LL4sw-187-0994-SW	Yes	8/14/01	
MH W3	LL4-188	LL4sw-188-0996-SW	Yes	8/20/01	
MH W1	LL4-189	LL4sw-189-0998-SW	Yes	8/13/01	
	LL4-189	LL4sw-189-1154-SW	Yes	8/13/01	Duplicate
	LL4-189	LL4sw-189-1172-SW	Yes	8/13/01	Split
MH 419	LL4-190	LL4sw-190–1000-SW	No		Location was dry
Ejector Station	LL4-191	LL4sw-191-1002-SW	No		Location was dry
MH E2	LL4-192	LL4sw-192-1004-SW	No		Location was dry

CN = Cyanide.
Exp = Explosives.
GS = Grain size.
PCB = Polychlorinated biphenys.
Prop = Propellants (nitrocellulose, nitroglycerine, nitroguanidine).
RI = Remedial Investigation.
SVOC = Semivolatile organic compound.
TOC = Total organic compound.
VOC = Volatile organic compound.

One water sample was collected from the Building G-8 washout basin (Table 3-4; Figure 3-6). This washout basin was also a focal point for water sampling because accumulated water within this structure may potentially contain residual contamination. Discharge or leakage from the basin represents potential secondary sources of contamination to surface water or groundwater. Additionally, residual water within the basin required characterization for the purpose of dispositions under any future demolition or remedial action.

Water samples were also collected from the seven locations within the storm and sanitary sewer systems; these are discussed in Section 3.5.

3.3.2 Surface Water Field Sampling Methods

All surface water samples were collected directly into sample containers as referenced in the Phase II RI SAP Addendum. Filtered samples were not collected. The sample container was submerged, with the cap in place, into the surface water. Then the container was slowly and continuously filled using the cap to regulate the rate of sample entry into the container. Surface water samples were collected prior to sediment samples at co-located sites also in an attempt to minimize the effects of sediment turbidity on surface water quality. In flowing streams, sample collection was initiated at the sampling point furthest downstream in the channel, and then proceeded to upstream sampling locations, to minimize the effects of sediment turbidity.

As a safety precaution, water samples from the Building G-8 washout basin was collected by UXO avoidance personnel. UXO avoidance personnel were trained by SAIC field staff on proper collection techniques prior to sampling. Upon collection of samples by UXO avoidance personnel, the samples were transferred to on-site SAIC field staff for sample packaging and shipping.

Field measurements were taken during sampling including pH, conductivity, dissolved oxygen content, and temperature. These measurements were performed in accordance with procedures contained in Section 4.3.3 of the Facility-wide SAP, as referenced by the Phase II RI SAP Addendum. All field measurements were recorded in the sampling logbooks.

3.4 GROUNDWATER CHARACTERIZATION

3.4.1 Rationale

The rationale for the installation and sampling of groundwater monitoring wells during the Phase II RI at Load Line 4 was to identify whether contaminants were present in groundwater at the AOC, determine the directions of groundwater flow and potential contaminant transport, quantify groundwater flow rates to the extent possible, and determine if any contamination was potentially migrating off of the AOC.

Eight new monitoring wells were installed during the Phase II RI. Figure 3-5 illustrates monitoring well locations. Five of the monitoring wells were installed adjacent to former process buildings and settling basins (in presumed downgradient locations based on topography and stream drainage) to maximize the potential to identify contaminated groundwater resulting from leaching at known and suspected source areas. Two wells were located along the southern boundary of the load line to monitor potential off-AOC transport of contamination. One well was located along the western boundary to provide an understanding of the flow regime within the AOC and to evaluate potential off-AOC transport in this area. Table 3-5 provides details for groundwater sampling during the Phase II RI.

3.4.2 Monitoring Well Installation Methods

All monitoring well installation activities were conducted according to the Facility-wide SAP and Load Line 4 Phase II RI SAP Addendum. All wells were completed in the unconsolidated zone. Monitoring wells were installed using hollow-stem auger drilling methods under the direct supervision of a qualified geologist. A 16.5-cm (4.25-in.) inside diameter, hollow-stem auger was used to advance the borehole through unconsolidated materials. Soil samples were collected continuously from the surface to bedrock refusal or planned borehole termination using a split-barrel sampler. Soil sampling was conducted during well drilling for description of soil stratigraphy in accordance with USCS using standard Munsell® Soil Color Charts (Munsell 1988). Only geotechnical samples were collected from monitoring well borings; samples for chemical analysis were not collected. The monitoring well boring logs are provided in Appendix C.

Table 3-5. Groundwater Sample List and Rationales, Load Line 4 Phase II RI

Station	Sample ID	Sample Collected (Yes/No)	Date Sampled	Associated Trip Blank	Shelby Tube Sample ID	Comments/Rationales Geotech Analyses
LL4-193	LL4mw-193-1006-GW	Yes	9/5/01	LL41182		
		Yes	7/26/01		LL4mw-193-1121-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		Yes	7/26/01		LL4mw-193-1122-SO	MC, BD, Porosity, pH, AL, SG, USCS
LL4-194	LL4mw-194-1108-GW	Yes	9/5/01	LL41182		
		Yes	7/26/01		LL4mw-194-1123-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		Yes	7/26/01		LL4mw-194-1124-SO	MC, BD, Porosity, pH, SG, USCS
LL4-195	LL4mw-195-1110-GW	Yes	9/4/01	LL41182		
		Yes	7/25/01		LL4mw-195-1125-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		Yes	7/25/01		LL4mw-195-1126-SO	MC, BD, Porosity, pH, AL, SG, USCS
LL4-196	LL4mw-196-1112-GW	Yes	9/5/01	LL41182		
		Yes	7/25/01		LL4mw-196-1127-SO	MC, GS, pH, AL, SG, USCS
		No			LL4mw-196-1128-SO	
LL4-197	LL4mw-197-1114-GW	Yes	9/7/01	LL41183		
		Yes	7/25/01		LL4mw-197-1129-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		No			LL4mw-197-1130-SO	Not collected
LL4-198	LL4mw-198-1116-GW	Yes	9/6/01	LL41183		
		Yes	7/26/01		LL4mw-198-1131-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		No			LL4mw-198-1132-SO	Not collected
LL4-199	LL4mw-199-1118-GW	Yes	9/6/01	LL41182		
		Yes	7/25/01		LL4mw-199-1133-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		Yes	7/25/01		LL4mw-199-1134-SO	MC, pH, SG, USCS
LL4-199	LL4mw-199-1152-GW	Yes	9/6/01	LL41182		Duplicate
LL4-199	LL4mw-199-1170-GW	Yes	9/6/01	LL41182		Split
LL4-200	LL4mw-200–1120-GW	Yes	9/6/01	LL41183		
		Yes	7/24/01		LL4mw-200–1135-SO	MC, BD, Porosity, GS, pH, AL, HC, SG, USCS
		Yes	7/24/01		LL4mw-200–1136-SO	MC, BD, Porosity, pH, AL, SG, USCS

AL = Atterberg limits.
BD = Bulk density.
CN = Cyanide.
Exp = Explosives.
GF = Groundwater, filtered.
GS = Grain size.
GW = Groundwater, non-filtered.
HC = Hydraulic conductivity.
ID = Identification.
MC = Moisture content.
PCB = Polychlorinated biphenyl.
Prop = Propellants (nitrocellulose, nitroglycerine, nitroguanidine).
SG = Specific gravity.
SVOC = Semivolatile organic compound.
USCS = Unified Soil Classification System.
VOC = Volatile organic compound.

Organic vapors were monitored from soil and rock cuttings at each borehole using a hand-held organic vapor analyzer; however, samples for headspace readings were not collected. In addition, the breathing zone was monitored for evidence of organic chemicals. All readings are recorded in the project logbooks.

Upon reaching the approximate target depth for each boring, drilling operations were halted for approximately 1 hr to determine the amount of groundwater recharge. The objective for this step was to ensure that at least one-half of the screened interval for each well was below the water table. If sufficient groundwater recovery occurred, the field crew proceeded with construction of the monitoring well. If a sufficient water column was not present, the boring was advanced further.

Following drilling of the boreholes to the appropriate depths, monitoring wells were constructed from pre-cleaned 5.0-cm (2.0-in.) schedule 40 polyvinyl chloride pipe. Well screens were commercially fabricated with slot widths of 0.125 cm (0.005 in.) or 0.025 cm (0.01 in.). The monitoring wells were constructed using 3-m (10-ft) screens. The well casing and screen were assembled and lowered into the open borehole. Following placement of the well casing and screen, a pre-washed filter pack, consisting of Global Supply No. 5 clean silica sand, was tremied in place from the bottom of the borehole to approximately 0.6 m (2 ft) above the top of the well screen in each well. A 0.6-m (2-ft) or 0.9-m (3-ft) bentonite pellet annular seal was then poured into the borehole on top of the filter pack. A small quantity of potable water was added to hydrate the bentonite seal prior to grouting.

For monitoring well completion, a grout mixture consisting of Type I Portland cement and 5% bentonite was then tremied from the top of the annular seal to approximately 0.6 m (2 ft) bgs. A protective steel surface casing with locking cover, mortar collar, and cement pad was then constructed. A minimum of three, or four as required by site conditions, steel posts were installed around each well and were painted and labeled. Table 3-6 presents a summary of monitoring well construction details.

Table 3-6. Summary of Load Line 4 Phase II RI Monitoring Well Construction Data

Well ID	Total Depth (ft bgs)	Ground Elevation (ft amsl)	TOC Elevation (ft amsl)	Screened Interval (ft bgs)	Stratigraphy in Screened Interval
LL4mw-193	21.9	980.88	982.92	11.3 to 21.3	Sandy silt to silty clay
LL4mw-194	22.0	981.87	983.76	11.3 to 21.3	Silty clay
LL4mw-195	21.0	980.83	982.59	10.3 to 20.3	Fine-grained sand upper half; clayey silt in lower half
LL4mw-196	20.0	982.56	984.55	9.2 to 19.2	Fine-grained sand
LL4mw-197	21.7	983.79	985.46	10.8 to 20.8	Very fine-grained silty sand upper half; clay in lower half
LL4mw-198	22.0	981.61	983.42	10.3 to 20.3	Silt to silty clay
LL4mw-199	22.0	975.20	977.28	10.3 to 20.3	Silty clay with silty sand at bottom of interval
LL4mw-200	23.5	985.97	987.93	12.6 to 22.6	Very fine-grained silty sand

amsl = Above mean sea level.
bgs = Below ground surface.
ID = Identification.
RI = Remedial Investigation.
TOC = Top of casing.

3.4.3 Well Development Methods

At least 48 hrs after completion, each monitoring well was developed so that representative groundwater samples could be collected. As specified in the SAP Addendum for Load Lines 2, 3, and 4, well development was accomplished by purging at least five well volumes of groundwater, using a submersible pump or a bailer, until the development water was visually clear or the maximum development time (48 hr) had expired and sediment thickness in the well was less than 3.0 cm (0.1 ft). Well development records were included in the project logbooks and are provided in Appendix C.

3.4.4 Groundwater Field Sampling Methods

Following development of the new wells, groundwater samples were collected. The procedure for sampling groundwater is described in Sections 4.3.4 and 4.3.5 of the Facility-wide SAP. Before sampling, the monitoring wells were purged until readings of pH, conductivity, dissolved oxygen, and water temperature reached equilibrium. Groundwater samples were collected using a bladder pump following low-flow sampling procedures where there was sufficient water. General groundwater quality indicator parameters (pH, specific conductance, dissolved oxygen, temperature, and turbidity) were monitoring during the sampling procedure using a flow-through cell. If insufficient water was present in the well to allow for low-flow sampling techniques, the well was purged dry using a dedicated disposable bailer, allowed to recover, and then sampled using the bailer.

All groundwater samples were analyzed for explosives, propellants, TAL metals (filtered only), cyanide, VOCs, SVOCs, and pesticides/PCBs. Groundwater samples analyzed for dissolved metals were filtered during sample collection using either a disposable, in-line barrel filter or a disposable filter using negative pressure pump, both with 0.45-μm pores. The results of groundwater sampling at Load Line 4 are discussed in detail in Section 4.6. The analytical data are presented in Appendix I.

At wells LL4mw-197 and -198, turbidity readings greater than 999 nephelometric turbidity units (NTUs) remained following development, despite pumping each well dry twice. To get the most representative sample possible, sampling took place after other indicator parameters had stabilized. Only filtered groundwater samples were collected for inorganic analyses. At LL4mw-197, sampling was performed using micropurge methods to minimize turbidity to the extent possible. A bailer was used in well LL4mw-198 due to slow recharge.

3.4.5 In-Situ Permeability Testing

Slug tests were performed at all monitoring wells to determine the hydraulic conductivity of the geologic materials surrounding each well screen. Slug tests followed the provisions of the Phase II RI SAP Addendum. These analyses calculate horizontal hydraulic conductivities in the screened interval of each well. Rising-head slug test were conducted in all wells. The rising-head test was performed by inserting the slug and allowing the water level to equilibrate. To start the test, the slug was removed and the rise in water level was monitored. The tests were performed after each well had fully recovered from groundwater sampling. The slug employed for all tests was designed to displace 0.3 m (1 ft) of water.

Pressure transducers and data loggers were used for automated data collection during slug tests. Water level measurements were recorded using a pre-programmed logarithmic time interval. Water levels were monitored for a period of 6 hrs or until the well re-equilibrated to 90% of the pretest water level. The data were evaluated using AqteSolve™ software and hydraulic conductivity values were derived using the updated Bouwer and Rice method (Bouwer 1989, Butler 1998). Compensation for water levels within the screened interval is included in this evaluation method. The results of the slug tests are presented in Appendix F and are discussed in Chapter 2.0.

3.4.6 Groundwater Level Measurements

In order to determine the hydraulic gradient and flow directions across Load Line 4, as well as throughout RVAAP, a complete round of water level measurements was obtained from all accessible monitoring wells at the facility during the Phase II RI field effort (August 2001). Water level measurements were obtained over a 2-day period and reflected base flow conditions. Measurements were obtained using an electric water level indicator and measured to the nearest 0.01 ft. Potentiometric data for Load Line 4 and the RVAAP facility are discussed in Chapter 2.0.

3.5 SEWER LINE SAMPLING AND VIDEO CAMERA SURVEY

3.5.1 Rationale

Migration of contaminants to surface water (by flushing during storm events) or groundwater (through leaking or breached sewer pipe) from the sanitary and storm sewer systems at Load Line 4 may represent an un-quantified source release mechanism. Investigations of storm and sanitary lines at other army ammunition plants for load lines has shown that sewer lines are commonly contaminated with bulk explosives, particularly at load lines that were heavily used. Frequently, camera surveys of such lines reveal cracks or other breaches in the pipe. To characterize the sanitary and storm sewer systems for the presence of residual contaminants and to provide data for the evaluation of remedial alternatives, if any, sediment and water samples were collected at selected access points (manholes/inlets) where sufficient quantities of these media had accumulated. To assess the presence of accumulated explosives, integrity of the pipe, and their potential of releasing contaminants to the environment, a color video survey of the existing sewer systems at Load Line 4 was attempted. Results of the sewer system inspection are contained in Section 4.7.

3.5.2 Sediment and Water Sampling

Six of the eight planned sediment samples were collected from sanitary sewer manholes (Table 3-3; Figure 3-7). An insufficient volume of sediment was present for sampling at the Ejector Station and manhole E6. Co-located samples of water that had accumulated in the sanitary sewer line were collected as planned from four of the seven sanitary sewer manholes (stations LL4-186, LL4-187, LL4-188, and LL4-189); the remaining stations were dry.

Three of nine planned sediment samples were collected from the storm sewer system (manholes and inlets). Samples could not be collected from the remaining storm sewer sampling stations because they lacked sufficient sediment volume. Three of four planned water samples were collected from the storm sewer system.

Sampling of water from the sewer systems was performed prior to sediment sampling to ensure that the water was free from excess turbidity. Where sufficient water volume was present, samples were retrieved using a disposable bailer. The bailer was lowered into the sewer manhole from the surface using a nylon rope and retrieved as many times as necessary to provide the required sample volume. Sample containers for VOC analyses were collected first. Samples for metals analyses were not filtered.

Where the depth of the inlet allowed, collection of sediment samples from storm sewer inlets was conducted using a decontaminated stainless steel spoon or scoop. Collection of sediment samples from deep inlets and sewer system manholes was performed using an Eckmann sampler. The Eckmann sampler is a clamshell device with spring-activated doors that are deployed using a cable or extension rod. The decontaminated sampler was lowered to the sediment interface and the doors actuated to entrap sediment. The sampler was then raised to the surface and the sediment emptied into a decontaminated stainless steel bowl. This process was repeated until sufficient sediment volume has been obtained to fill sample containers.

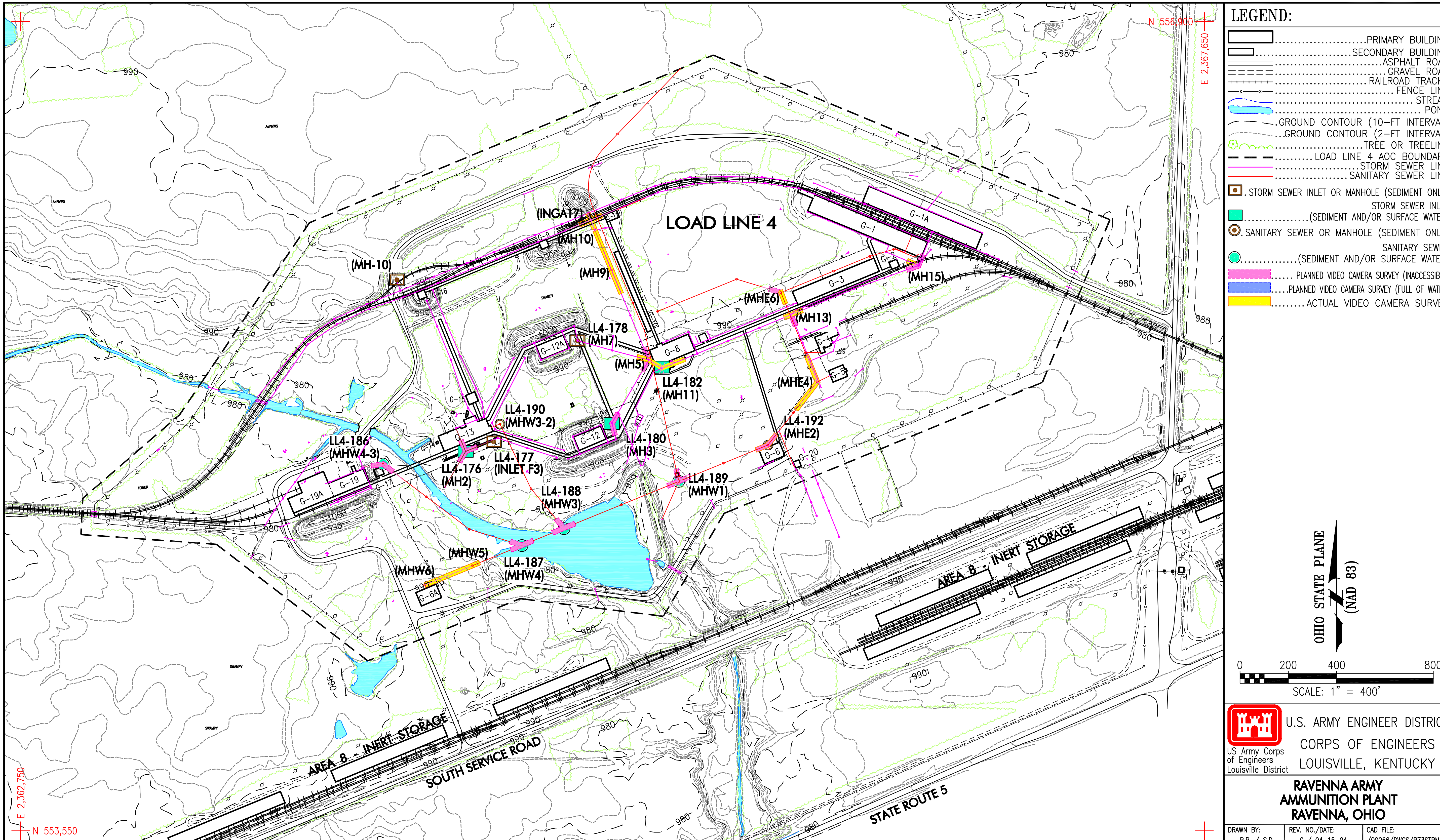

Figure 3-7. Phase II RI Storm and Sanitary Sewer Sampling and Video Camera Survey Locations at Load Line 4

For both methods of sediment sampling, aliquots for VOC analyses were collected directly from the sampling device from the first material obtained. A volume of sediment was placed into a stainless steel bowl, homogenized using a decontaminated stainless steel spoon or scoop, and samples for nonvolatile constituent analyses were obtained. During sample collection, all samples were field screened for VOCs using a hand-held photoionization detector. No headspace samples were collected for organic vapor monitoring.

3.5.3 Video Camera Survey

The video camera survey was biased to the portions of the system located near production areas of the load lines. Approximately 6% (1,500 linear ft) of the sewer system was surveyed. The camera survey was performed using a motorized camera assembly with fiber-optic cable. The camera assembly was capable of maneuvering in pipes as small as 10 cm (4 in.) in diameter and was capable of imaging the entire periphery of a pipes ranging from 20 cm (8 in.) to 76 cm (30 in.) in diameter.

The camera was maneuvered through the pipeline at a uniformly slow rate and the operator provided voice narrative to point out important features and the direction and speed of camera travel. Besides the video and voice record, a written inspection log was completed, which denoted locations of reference points and entry points, obstructions, cracks or other structural deficiencies. The surveys were recorded on videotape and the video camera survey inspection log is contained in Appendix N.

Table 3-7 presents the planned video camera survey along with a summary of the actual direction and footages videotaped. The sanitary sewer system was found to be largely flooded and several of the planned entry points were obstructed with debris (leaves, sticks, and sediment). No attempts were made to survey flooded lines as placement of the track camera in the pipes caused sediment to be re-suspended, which prevented video observation. Section 4.7 discusses results for the video camera survey at Load Line 4.

Table 3-7. Storm and Sanitary Sewer Line Video Camera Survey Summary

Manhole	Planned Direction/Footage	Actual Direction/Footage
Load Line 4 Storm Sewer		
MH-2	SW/50, N/50, E/50	Inaccessible
MH-3	NE/50, S/50	Inaccessible
MH-5	NW/50, N/50, NE/50, SE/50, SW/50	Towards MH7/15
MH-9	N/50, E/50, S/50	S/104
MH-10	Not planned	S/175
MH-11	NW/50, E/50	NW/67, E100
MH-13	W/50, E/50, S/50	W/26, E/50
MH-15	W/50, NW/50, NE/50	W/175
INGA-17	Not planned	N/29, E/51, W/50, S/50
Load Line 4 Sanitary Sewer		
MH-W1	W/50, N/50, E/50	Full of water
MH-W3	W/50, N/50, E/50	Full of water
MH-W4	W/50, NE/50, E/50	Full of water
MH-W4-3	W/50, S/50	Full of water
MH-W5	Not planned	Towards W4/31
MH-419	N/50, E/50, S/50	Manhole does not exist
MH-E2	W/50, NE/50	Too turbid for survey
MH-E4	Not planned	SW/145, N/113
MH-E6	NW/50, E/50, S/50	E/10, S/50
MH-W6	Not planned	E/213

3.6 TOPOGRAPHIC SURVEY

A topographic survey was performed by a surveying subcontractor at the conclusion of the Phase II RI field investigation. All plane and vertical surveys were conducted under the supervision of an Ohio-registered land surveyor. Final coordinates were converted to a state plane coordinate system and both North American Datum 1927 and 1983 coordinates reported. All horizontal locations were surveyed to the nearest 0.03 m (0.1 ft), and all elevations to the nearest 0.003 m (0.01 ft). Sample locations inside of buildings were not surveyed. Field activities included the following:

- Surveying soil, sediment, and surface water sampling locations.
- Establishing final locations, ground surface elevations, and top-of-casing elevations for all new monitoring wells.

3.7 ANALYTICAL PROGRAM OVERVIEW

3.7.1 Field Analysis for Explosives Compounds

All surface soil and sediment samples were field analyzed with colorimetric methods for TNT and RDX. The purpose of the analysis was to define the extent of surface soil contamination with respect to these explosive compounds. Field colorimetry was also used as a screening method to reduce the number of samples that required fixed-base laboratory analysis for explosives. Figure 3-4 illustrates the application of field analyses of explosives during the Phase II RI. The colorimetric data are considered as bulk values for TNT and RDX as discussed below (e.g., other explosives compounds may also be present and inflate the apparent TNT concentration). The methods may be used as a screening tool and to help map contaminant nature and extent. However, the method cannot be used in human health risk or ecological risk assessments because the quantitative risk calculations require that each compound must be evaluated individually.

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

A full discussion and comparison of the field screening and laboratory results for field TNT and RDX is presented in Section 4.11.

3.7.2 Geotechnical Analyses

The geotechnical sampling and analysis program conducted during the Phase II RI for Load Line 4 involved the collection and analysis of surface soil, subsurface soil, and sediment. Samples collected during the investigation were analyzed by S&ME of Knoxville, Tennessee, a USACE Center of Excellence (CX)-certified laboratory. Soil samples collected using the bucket hand auger method are classified as disturbed samples. Soil samples collected directly from the bucket of the track hoe used to excavate test pits are also classified as disturbed samples. Geotechnical analysis of samples collected using these methods was limited to grain size distribution, Atterberg limits, moisture content, USCS classification, pH analysis, and specific gravity. Each soil sample collected was visually classified in the field according to USCS. Disturbed sediment samples (e.g., collected using manual methods) were also visually classified in the field and submitted for grain size distribution and TOC by chemical analysis. The results of the geotechnical evaluation for soils and sediment samples are discussed in Chapter 4.0 and included in Appendix K.

In addition to disturbed samples, Shelby tubes were used to collect 13 undisturbed samples from monitoring well locations (Table 3-5). Shelby tube samples were collected from within the planned monitoring interval of each of the eight monitoring wells. In addition, Shelby tube samples from near surface intervals were collected from five wells. Shelby tube samples were submitted for a comprehensive suite of parameters to evaluate site hydrogeologic characteristics and to support development of future remedial alternatives. Geotechnical analytical parameters for undisturbed samples included moisture content, grain size distribution, USCS, Atterberg limits, hydraulic conductivity, specific gravity, bulk density, porosity, and pH.

3.7.3 Laboratory Analyses

The chemical sampling and analysis program conducted during the Phase II RI involved the collection and analysis of surface soil, subsurface soil, sediment, surface water, groundwater, and miscellaneous solid materials (floor sweep debris). Independent QA analyses were conducted by an analytical laboratory under contract with USACE, Louisville District.

Samples collected during the investigation were analyzed by Severn Trent Laboratories (STL), North Canton, Ohio, an USACE CX-certified laboratory. QA samples were collected of soil, sediment, surface water, and groundwater and were analyzed by USACE's contracted QA laboratory, GP Environmental, Inc., located in Gaithersburg, Maryland. Laboratories supporting this work have statements of qualifications including organizational structures, QA manuals, and standard operating procedures, which can be made available upon request.

Samples were collected and analyzed according to the Facility-wide SAP and the Load Line 2, 3, and 4 Phase II RI SAP Addendum. Prepared in accordance with USACE and EPA guidance, the Facility-wide SAP and associated addenda outline the organization, objectives, intended data uses, and QA/QC activities to achieve the desired DQOs and to maintain the defensibility of the data. Project DQOs were established in accordance with EPA Region V guidance. Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for the Phase II RI are consistent with EPA requirements for National Priorities List sites. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix H presents an assessment of those objectives as they apply to the analytical program.

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

The types of QA/QC samples for this project included field blanks, trip blanks, QA field duplicates, laboratory method blanks, laboratory control samples (LCSs), laboratory duplicates, matrix spike/matrix spike duplicate samples, and QC field split samples (submitted to the independent USACE contracted laboratory). Field blanks, consisting of potable water used in the decontamination process, equipment rinsate blanks, and trip blanks were submitted for analysis, along with field duplicate samples, to provide a means to assess the quality of the data resulting from the field sampling program. Table 3-8 presents a summary of QA/QC samples utilized during the Phase II RI. Evaluation of these QA/QC samples and their contribution to documenting the project data quality is provided in the Data Quality Assessment (DQA) Report in Appendix H.

Table 3-8. Summary of QA/QC Samples, Load Line 4 Phase II RI

Sample Type	Rationale
Field Blank	Analyzed to determine procedural contamination at the site that may contribute to sample contamination
Trip Blank	Analyzed to assess the potential for contamination of samples due to contaminant interference during sample shipment and storage
Field Duplicate	Analyzed to determine sample heterogeneity and sampling methodology reproducibility
Equipment Rinsate	Analyzed to assess the adequacy of the equipment decontamination processes for soil and groundwater
Laboratory Method Blanks	Analyzed to determine the accuracy and precision of the analytical method as implemented by the laboratory
Laboratory Duplicate Samples	Analyzed to assist in determining the analytical reproducibility and precision of the analysis for the samples of interest and provide information about the effect of the sample matrix on the measurement methodology
Matrix Spike/Matrix Spike Duplicate	
QC Split	Analyzed to provide independent verification of the accuracy and precision of the principal analytical laboratory

QA = Quality assurance.
QC = Quality control.
RI = Remedial Investigation.

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

3.7.4 Data Review, Validation, and Quality Assessment

Samples were properly packaged for shipment and dispatched to STL for analysis. A separate signed custody record with sample numbers and locations listed was enclosed with each shipment. When transferring the possession of samples, the individuals who relinquished and received the samples signed, dated, and noted the time on the record. All shipments were in compliance with applicable U. S. Department of Transportation regulations for environmental samples.

Data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the Load Line 4 Phase II RI Quality Assurance Project Plan (QAPP) Addendum, the Louisville District analytical QA guidelines, and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance. As discussed in the DQA Report (Appendix H, Section 4.3), the laboratory experienced difficulties with SVOC extractions and sample matrix interferences. Because of these issues, the holding times for SVOC extractions were exceeded and all results were qualified as estimated (J-qualified).

STL performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing SAIC and

USACE of any data that are considered "unacceptable" or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and standard operating procedures. Data reduction, review, and reporting by the laboratory were conducted as follows.

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria, as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the laboratory project manager.
- The laboratory project manager completed a thorough review of all reports.
- The laboratory project manager generated the final reports.

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

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

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

Independent data validation was performed by Lee A. Knuppel and Associates under a separate task with the Louisville USACE. This review constituted comprehensive validation of 10% of the primary data set; comprehensive validation of the QA split sample data set; and a comparison of primary sample, field duplicate sample, and field QA split sample information.

3.8 ORDNANCE AND EXPLOSIVE AVOIDANCE AND FIELD RECONNAISSANCE

OE avoidance subcontractor support staff were present during all field operations, except groundwater sampling. The OE team leader led an initial safety briefing on OE to train all field personnel to recognize and stay away from propellants and OE. Daily tailgate safety briefings included reminders regarding OE avoidance. Site visitors were briefed on OE avoidance prior to allowing access into the AOC.

Prior to beginning sampling activities, access routes into areas from which samples were to be collected were assessed for potential OE using visual surveys and hand-held magnetometers. The OE team leader, USACE technical representative, and SAIC technical manager located each proposed sampling station, monitoring well, and test trench within the AOC using a steel pin flag with the sample station identification number. The pin flag was placed at a point approved by the OE technician.

An OE technician remained with the sampling crews as work progressed. At stations where subsurface soil samples were to be collected from 0.3 to 0.9 m (1 to 3 ft) bgs, a magnetometer was lowered into the borehole to screen for subsurface magnetic anomalies at the top of the subsurface interval. Where circumstances dictated that the borehole be deepened beyond 3 ft bgs, a magnetometer reading was taken at the top of each subsequent 2-ft interval prior to augering.

For monitoring well borings, OE technicians screened the locations by hand augering to a minimum depth of at least 0.9 m (3 ft) or 0.6 m (2 ft) below original undisturbed soil, whichever was more, and performing downhole magnetometer readings at 0.6-m (2-ft) intervals. The OE technician remained on-site as drilling was performed to visually examine drill cuttings for any unusual materials indicative of potential OE. OE technicians also provided sampling support for the Building G-8 washout basin (sediment and water), as described in Sections 3.2.2 and 3.3.2.

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